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EFFECTS OF VARIATIONS IN NOSE AND WINDSHIELD GEOMETRY ON SUPERSONIC AERODYNAMIC CHARACTERISTICS OF A VARIABLE-SWEEP TACTICAL FIGHTER MODEL

by Celia S. Richardson

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SUMMARY

An investigation has been made in the low Mach number test section of the Langley Unitary Plan wind tunnel to determine the effects of various nose and windshield shapes on the aerodynamic characteristics of a current multimission tactical fighter model. Tests were performed for a wing leading-edge sweep of 72.5° at Mach numbers of 1.6, 2.16, and 2.50, at angles of attack from about -2° to 20°, and at angles of sideslip of about 0° and 4°. The Reynolds number per foot was 3.0×10^{6}. In order to expedite publication, no detailed analysis of these data has been made. However, the data indicate that each of the forebody modifications, which resulted in forebodies somewhat longer than the basic forebody, generally caused a slight increase in minimum drag and a reduction in directional stability.

INTRODUCTION

The National Aeronautics and Space Administration is currently conducting wind-tunnel studies directed toward the development of a multimission, variable-sweep-wing, tactical fighter aircraft for use by the military services. References 1 to 15 present some of the results of these studies.

The current test was performed to determine the effects of variation in windshield and nose geometry on the aerodynamic characteristics of the model. In addition to the basic model, six configurations combining variations in nose and windshield design were tested. Tests with and without an IR tracker were also included for two of the configurations.

The tests were performed for a wing leading-edge sweep angle of 72.5° at Mach numbers of 1.6, 2.16, and 2.50, at angles of attack from about -2° to 20°, and at angles of sideslip of about 0° and 4°. The Reynolds number per foot was 3.0×10^{6}. In order to expedite publication, no analysis of these data has been made.

SYMBOLS

The results of this investigation are presented as force and moment coefficients, with the longitudinal characteristics referred to the stability-axis system and the lateral parameters referred to the body-axis system. The data are based on the geometry of the wing in a 16° sweptback position (see table I) in order to be compatible with data from references 1 to 15.

b	wing span, in.
$\bar{c}$	wing mean aerodynamic chord, in.
C_D	drag coefficient, $\frac{\text{Drag}}{qS}$
$C_{D,b}$	duct-exit-plug base-drag coefficient, $\frac{\text{Duct-exit-plug base drag}}{qS}$
$C_{D,c}$	fuselage-chamber-drag coefficient, $\frac{\text{Chamber drag}}{qS}$
$C_{D,i}$	internal-drag coefficient, $\frac{\text{Internal drag}}{qS}$
C_L	lift coefficient, $\frac{\text{Lift}}{qS}$
C_l	rolling-moment coefficient, $\frac{\text{Rolling moment}}{qSb}$
C_{l_β}	effective-dihedral parameter, $\frac{\Delta C_l}{\Delta \beta}$, per deg
C_m	pitching-moment coefficient, $\frac{\text{Pitching moment}}{qS\bar{c}}$
C_n	yawing-moment coefficient, $\frac{\text{Yawing moment}}{qSb}$
C_{n_β}	directional-stability parameter, $\frac{\Delta C_n}{\Delta \beta}$, per deg

C_Y	side-force coefficient, $\frac{\text{Side force}}{qS}$
C_{Y_β}	side-force parameter, $\frac{\Delta C_Y}{\Delta \beta}$, per deg
L/D	lift-drag ratio
M	free-stream Mach number
p_t	stagnation pressure, lb/sq in. abs
q	free-stream dynamic pressure, lb/sq ft
r	radius, in.
S	wing area, sq ft
T_t	stagnation temperature, $^{\circ}$F
α	angle of attack of wing (wing reference chord at $+1^{\circ}$ incidence to water line), deg
β	angle of sideslip of model center line, deg
Λ	wing leading-edge sweep angle, deg

Abbreviations:

B.L.	buttock line
F.S.	fuselage station
W.L.	water line

APPARATUS

Tunnel

Tests were conducted in the low Mach number test section of the Langley Unitary Plan wind tunnel, which is a variable-pressure, continuous-flow tunnel. The test section

is 4 feet square and approximately 7 feet long. The nozzle leading to the test section is of the asymmetric sliding-block type which permits a continuous variation in test-section Mach number from about 1.5 to 2.9.

Model

Details of the 1/24-scale model are shown in figure 1(a), and reference quantities used in data reduction are presented in table I. The model is a high-wing configuration with the variable-sweep wing at 1° incidence with respect to the water lines, and has a wing glove faired into the fuselage. Details of the variations in nose geometry and windshield angle are presented in figure 1(b), and the buttock-line and water-line ordinates at various fuselage stations are presented for each configuration in table II.

In order to relate the model components of this report with those of previous reports, the following table shows the model component identification:

Component	Designation	Component	Designation
Nose	B_{24a}	Inlet spike	I_{43}
	B_{64}		
	B_{66}	Nozzle	N_{32}
	B_{67}		
	B_{68}	Ventral fin	V_{29}
	B_{69}		
	B_{71}	Vertical tail	V_{38}
Wing	W_{29a}	Dorsel fairing	X_{25}
Wing glove	G_{17}	IR tracker	X_{52}
Horizontal tail	H_{13}		

Note: Unless otherwise indicated, all configurations in the present report were $B_{24a}G_{17}H_{13}I_{43}N_{32}V_{29}V_{38}W_{29a}X_{25}X_{52}$ with $\Lambda = 72.5^{\circ}$.

PROCEDURE

Test Conditions

The following table presents the conditions at which the tests were performed:

M	T_t, °F	p_t, lb/sq in. abs	Reynolds number per foot
1.60	150	11.89	3.0×10^6
2.16	150	14.87	3.0
2.50	150	17.61	3.0

The dewpoint, measured at stagnation pressure, was maintained below -30° F for all tests in order to assure negligible condensation effects.

All configurations incorporated 1/16-inch-wide transition strips composed of No. 80 carborundum grit (nominal diameter of 0.008 inch) embedded in acrylic plastic. These strips were located 1/2 inch rearward (streamwise) on the wing, wing glove, horizontal and vertical tails, and ventral fins. In addition, a 1/16-inch-wide transition band was placed 1 inch rearward around the model nose.

Measurements

Aerodynamic forces and moments were measured by means of a six-component electrical strain-gage balance housed within the model. The balance in turn was rigidly fastened to a sting support system. Fuselage-chamber pressure and duct-exit-plug base pressure were measured by means of a single static orifice located in the balance cavity and at the duct-exit-plug base, respectively.

Corrections

Angles of attack have been corrected for tunnel-flow angularities, and angles of attack and sideslip have been corrected for deflection of sting and balance caused by aerodynamic loads. The drag data have been adjusted to a condition of free-stream pressure acting over the fuselage chamber and duct-exit-plug bases. In addition, the drag data have been adjusted to zero momentum and pressure losses at the duct exits. Typical values of the drag corrections are presented in figure 2.

PRESENTATION OF RESULTS

In order to expedite publication, no analysis of the results obtained in this investigation has been made. The results are presented in the following figures:

Longitudinal Characteristics

Lateral Parameters

CONCLUDING REMARKS

A wind-tunnel investigation has been conducted at Mach numbers of 1.60, 2.16, and 2.50, at angles of attack from about -2° to 20°, and at angles of sideslip of about 0° and 4° to determine the effects of variation in windshield and nose geometry on the aerodynamic characteristics of a variable-sweep tactical fighter model. In order to expedite publication, no detailed analysis of these data has been made. However, the data indicate that each of the forebody modifications, which resulted in forebodies somewhat longer than the basic forebody, generally caused a slight increase in minimum drag and a reduction in directional stability.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., May 27, 1968,
720-01-00-18-23.

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TABLE I.- REFERENCE QUANTITIES USED IN DATA REDUCTION

[All quantities are model scale and are based on $\Lambda = 16^{\circ}$]

Wing area*, S, sq ft	0.955
Wing span, b, in.	35.000
Wing mean aerodynamic chord, $\bar{c}$, in.	4.400
Moment reference:	
Fuselage station, in.	22.028
Water line, in.	7.367
Angle-of-attack reference	Wing reference line (at 1° incidence to water line)
Fuselage-chamber area, sq ft	0.012531
Duct-inlet area (one side), sq ft	0.012948
Duct-exit area (one side), sq ft	0.014142
Duct-exit-plug base area, sq ft	0.016433
Duct-exit angle with respect to wing reference line, deg	-4.53

*The reference wing area was obtained by extending the leading and trailing edges of the 16° sweptback wing to the model center line.

TABLE II.- BUTTOCK-LINE AND WATER-LINE ORDINATES AT VARIOUS FUSELAGE STATIONS FOR DIFFERENT CONFIGURATIONS

[All values are in inches; for fuselage stations at which there are no variations in the lower fuselage contour, the B.L. and W.L. values are given to the maximum B.L. values only.]

(a) Configuration B_{24a} (origin at F.S. 3.625, W.L. 6.507; nose radius of 0.065)

F.S. 3.750		F.S. 4.167		F.S. 4.583		F.S. 5.000		F.S. 5.417		F.S. 5.833	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	6.606	0	6.824	0	6.962	0	7.109	0	7.256	0	7.403
.043	6.595	.119	6.753	.137	6.949	.163	7.069	.186	7.241	.219	7.384
.073	6.581	.209	6.731	.248	6.911	.318	7.051	.350	7.199	.423	7.328
.093	6.554	.287	6.629	.321	6.864	.428	6.984	.524	7.106	.607	7.227
.101	6.544	.306	6.528	.424	6.754	.524	6.892	.659	6.966	.751	7.084
.085	6.456	.295	6.444	.476	6.640	.595	6.786	.750	6.789	.856	6.898
.039	6.420	.226	6.342	.488	6.553	.629	6.689	.777	6.614	.899	6.663
0	6.413	.088	6.294	.445	6.394	.641	6.566	.756	6.459	.886	6.493
		0	6.272	.336	6.271	.606	6.412	.706	6.337	.794	6.271
				.191	6.193	.521	6.278	.627	6.229	.654	6.124
				0	6.161	.403	6.180	.481	6.116	.454	6.016
						.270	6.116	.312	6.043	.216	5.957
						.116	6.079	.162	6.011	0	5.942
						0	6.072	0	6.000		

F.S. 6.250		F.S. 6.667		F.S. 7.083		F.S. 7.500		F.S. 8.750		F.S. 9.583	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	7.550	0	7.698	0	7.844	0	7.991	0	8.487	0	8.817
.214	7.534	.225	7.679	.214	7.824	.188	7.972	.091	8.483	.201	8.800
.408	7.488	.456	7.631	.436	7.769	.409	7.913	.225	8.463	.337	8.768
.570	7.419	.605	7.557	.633	7.690	.654	7.808	.356	8.428	.469	8.719
.679	7.348	.743	7.469	.795	7.589	.833	7.694	.482	8.375	.594	8.656
.797	7.241	.869	7.353	.933	7.456	.997	7.536	.601	8.308	.713	8.577
.909	7.096	.976	7.215	1.056	7.281	1.107	7.382	.754	8.190	.822	8.484
.971	6.961	1.051	7.068	1.141	7.088	1.176	7.241	.886	8.046	.920	8.379
1.006	6.805	1.096	6.907	1.181	6.914	1.228	7.069	.993	7.884	1.006	8.262
1.013	6.670	1.111	6.696	1.189	6.794	1.248	6.868	1.079	7.798	1.079	8.136
.991	6.474	1.101	6.563	Straight line		Straight line		1.159	7.698	1.136	8.003
.921	6.296	1.078	6.449	1.188	6.719	1.247	6.739	1.223	7.588	1.210	7.894
.806	6.148	1.009	6.284	1.174	6.551	1.241	6.626	1.281	7.449	1.272	7.773
.664	6.040	.904	6.143	1.122	6.366	1.213	6.473	1.321	7.275	1.319	7.644
.482	5.959	.764	6.027	1.047	6.224	1.154	6.313	1.329	7.126	1.357	7.459
.225	5.904	.561	5.928	.911	6.069	1.038	6.134	Straight line		1.364	7.304
0	5.893	.338	5.871	.731	5.947	.919	6.018			Straight line	
		.078	5.852	.506	5.862	.775	5.923				
		Straight line		.298	5.826	.605	5.852				
		0	5.852	.137	5.818	.381	5.803				
				Straight line		.197	5.792				
				0	5.818	Straight line					
						0	5.792				

F.S. 10.417		F.S. 11.250		F.S. 12.083		F.S. 12.917		F.S. 13.750		F.S. 14.583	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	9.110	0	9.277	0	9.354	0	9.379	0	9.373	0	9.343
.164	9.099	.190	9.263	.075	9.352	.168	9.371	.051	9.373	.120	9.339
.306	9.073	.397	9.218	.231	9.336	.328	9.345	.153	9.366	.221	9.329
.446	9.030	.567	9.154	.413	9.294	.484	9.303	.288	9.349	.321	9.315
.606	8.958	.727	9.069	.589	9.230	.635	9.246	.421	9.321	.420	9.296
.754	8.864	.874	8.963	.755	9.144	.808	9.156	.551	9.283	.518	9.271
.910	8.731	.985	8.861	.909	9.038	.968	9.047	.678	9.235	.638	9.233
1.043	8.574	1.084	8.747	1.048	8.913	1.136	8.895	.800	9.177	.733	9.196
1.136	8.424	1.170	8.623	1.169	8.771	1.260	8.750	.918	9.109	.825	9.156
1.198	8.290	1.242	8.491	1.269	8.618	1.389	8.695	1.003	9.053	.915	9.109
1.252	8.123	1.298	8.351	1.349	8.576	1.535	8.623	1.104	8.975	.982	9.071
1.313	7.978	1.343	8.195	1.439	8.522	1.642	8.561	1.153	8.936	1.085	9.012
1.362	7.802	1.391	7.999	1.447	8.516	1.746	8.496	1.246	8.873	1.198	8.954
1.385	7.652	1.406	7.888	1.456	8.503	1.757	8.484	1.346	8.819	1.313	8.900
1.391	7.482	1.413	7.756	1.458	8.487	1.764	8.459	1.443	8.776	1.430	8.851
Straight line								1.561	8.729	1.519	8.818
								1.727	8.652	1.581	8.798
								1.889	8.566	1.706	8.753
								2.045	8.470	1.869	8.688
								2.058	8.457	1.998	8.630
								2.064	8.437	2.125	8.568
										2.249	8.500
										2.344	8.444
										2.353	8.438
										2.359	8.429
										2.363	8.418
										2.364	8.407

TABLE II.- BUTTOCK-LINE AND WATER-LINE ORDINATES AT VARIOUS FUSELAGE STATIONS FOR DIFFERENT CONFIGURATIONS – Continued

(b) Configuration B_{64} (origin at F.S. 2.688, W.L. 6.293; nose radius of 0.063)

F.S. 3.333		F.S. 4.167		F.S. 5.000		F.S. 5.833		F.S. 6.667		F.S. 7.167	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	6.684	0	6.988	0	7.238	0	7.463	0	7.692	0	7.820
.118	6.663	.135	6.976	.150	7.229	.128	7.457	.141	7.684	.144	7.817
.198	6.621	.287	6.935	.302	7.193	.260	7.436	.303	7.658	.289	7.796
.271	6.554	.428	6.857	.459	7.131	.389	7.398	.468	7.606	.478	7.744
.316	6.488	.518	6.767	.596	7.044	.529	7.342	.651	7.526	.684	7.654
.343	6.404	.583	6.668	.701	6.950	.647	7.277	.808	7.427	.856	7.542
.348	6.317	.623	6.531	.779	6.846	.749	7.200	.941	7.304	1.000	7.400
.326	6.229	.640	6.454	.839	6.734	.859	7.093	1.049	7.151	1.109	7.248
.299	6.158	.642	6.335	.875	6.611	.947	6.972	1.123	7.003	1.191	7.061
.249	6.093	.624	6.211	.889	6.490	1.013	6.843	1.165	6.853	1.224	6.871
.168	6.029	.588	6.092	.888	6.353	1.055	6.696	1.182	6.667	1.228	6.683
.103	6.001	.533	6.000	.875	6.227	1.071	6.531	1.178	6.508	1.215	6.499
0	5.987	.449	5.909	.849	6.109	1.063	6.368	1.160	6.346	1.182	6.325
		.343	5.842	.813	6.003	1.038	6.209	1.118	6.194	1.123	6.175
		.218	5.797	.744	5.909	.993	6.068	1.053	6.050	1.038	6.038
		.110	5.780	.652	5.819	.925	5.949	.953	5.929	.917	5.918
		0	5.776	.536	5.751	.838	5.856	.819	5.533	.756	5.819
				.408	5.703	.718	5.770	.658	5.758	.566	5.750
				.278	5.677	.573	5.708	.475	5.707	.379	5.717
				.141	5.663	.414	5.668	.273	5.683	.168	5.703
				0	5.660	.268	5.646	.144	5.678	0	5.701
						.138	5.638	0	5.673		
						0	5.634				

F.S. 7.500		F.S. 7.917		F.S. 8.333		F.S. 8.750		F.S. 9.167		F.S. 9.583	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	7.916	0	8.019	0	8.261	0	8.504	0	8.744	0	8.984
.144	7.906	.142	8.014	.154	8.253	.138	8.494	.128	8.738	.144	8.975
.313	7.878	.298	7.992	.280	8.224	.276	8.467	.272	8.709	.279	8.949
.501	7.827	.470	7.952	.438	8.166	.415	8.418	.428	8.656	.401	8.909
.688	7.753	.651	7.888	.578	8.086	.548	8.350	.567	8.584	.542	8.843
.873	7.638	.808	7.804	.688	8.004	.677	8.260	.697	8.492	.661	8.763
1.008	7.511	.948	7.694	.761	7.940	.797	8.150	.815	8.383	.773	8.670
1.116	7.366	1.061	7.573	.870	7.862	.883	8.044	.927	8.249	.882	8.557
1.201	7.188	1.153	7.435	.991	7.761	.965	7.928	1.016	8.103	.967	8.441
1.244	6.996	1.223	7.279	1.098	7.645	.999	7.877	1.094	7.938	1.046	8.308
1.249	6.826	1.263	7.110	1.187	7.513	1.091	7.789	1.146	7.848	1.113	8.168
1.246	6.648	1.276	6.931	1.258	7.359	1.171	7.688	1.223	7.728	1.142	8.083
1.229	6.483	1.274	6.756	1.296	7.200	1.233	7.578	1.286	7.588	1.166	7.998
1.186	6.308	1.263	6.591	1.308	7.033	1.294	7.421	1.348	7.223	1.204	7.904
1.109	6.151	1.234	6.428			1.321	7.266			1.260	7.799
1.008	6.012	1.175	6.265			1.331	7.091			1.310	7.673
.884	5.903	1.085	6.109							1.349	7.516
.750	5.825	.978	5.990							1.365	7.360
.583	5.763	.836	5.888								
.453	5.736	.689	5.817								
.296	5.721	.531	5.768								
.194	5.717	.368	5.746								
Straight line		.241	5.739								
0	5.717	Straight line									
		0	5.739								

F.S. 10.000		F.S. 10.417		F.S. 11.250		F.S. 12.083		F.S. 12.917		F.S. 13.333	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	9.193	0	9.300	0	9.420	0	9.443	0	9.424	0	9.401
.154	9.186	.169	9.290	.129	9.417	.161	9.435	.183	9.410	.139	9.392
.293	9.159	.344	9.251	.296	9.394	.303	9.413	.344	9.382	.279	9.374
.429	9.113	.477	9.204	.492	9.335	.461	9.367	.502	9.336	.423	9.343
.598	9.029	.628	9.130	.663	9.250	.624	9.303	.692	9.254	.600	9.283
.738	8.927	.761	9.041	.813	9.150	.756	9.227	.866	9.153	.751	9.213
.871	8.804	.889	8.928	.957	9.027	.909	9.117	1.021	9.034	.883	9.136
.973	8.674	1.016	8.780	1.071	8.888	1.051	8.981	1.141	8.915	1.023	9.034
1.061	8.525	1.103	8.644	1.150	8.763	1.167	8.838	1.224	8.816	1.141	8.926
1.133	8.364	1.169	8.504	1.219	8.627	1.243	8.730	1.281	8.735	1.253	8.800
1.184	8.197	1.211	8.382	1.268	8.495	1.303	8.594	1.427	8.666		
1.218	8.061	1.238	8.256	1.302	8.368			1.546	8.607		
1.244	7.973	1.254	8.119	1.326	8.239			1.658	8.542		
1.288	7.885	1.301	8.006	1.368	8.113			1.742	8.486		
1.328	7.771	1.343	7.882	1.395	7.973			1.755	8.474		
1.357	7.645	1.369	7.750	1.408	7.842			1.764	8.459		
1.373	7.518	1.386	7.609	1.414	7.701						
1.377	7.331	1.391	7.467								

TABLE II.- BUTTOCK-LINE AND WATER-LINE ORDINATES AT VARIOUS FUSELAGE STATIONS FOR DIFFERENT CONFIGURATIONS – Continued

(c) Configuration B_{66} (origin at F.S. 2.625, W.L. 6.093; nose radius of 0.067*)

F.S. 3.333		F.S. 3.750		F.S. 4.167		F.S. 5.000		F.S. 5.427		F.S. 5.833	
r	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0.365	6.165	0	6.687	0	6.838	0	7.122	0	7.255	0	7.377
		.138	6.672	.147	6.823	.156	7.113	.155	7.243	.172	7.360
		.210	6.648	.300	6.782	.267	7.092	.283	7.222	.328	7.332
		.297	6.602	.430	6.705	.408	7.045	.442	7.172	.528	7.260
		.382	6.532	.523	6.608	.527	6.983	.630	7.067	.738	7.128
		.445	6.440	.600	6.480	.635	6.900	.802	6.912	.912	6.938
		.488	6.323	.630	6.385	.763	6.750	.923	6.730	1.023	6.728
		.502	6.202	.647	6.253	.842	6.607	.975	6.560	1.068	6.457
		.495	6.103	.633	6.107	.875	6.463	.993	6.402	1.054	6.213
		.462	5.997	.580	5.947	.888	6.347	.985	6.213	.995	6.000
		.393	5.887	.495	5.822	.883	6.182	.952	6.045	.820	5.753
		.295	5.808	.352	5.722	.862	6.058	.873	5.862	.632	5.647
		.222	5.768	.272	5.692	.827	5.945	.768	5.740	.463	5.597
		.125	5.740	.158	5.667	.773	5.845	.625	5.650	.263	5.567
		0	5.728	0	5.653	.685	5.740	.468	5.593	0	5.555
						.563	5.658	.267	5.557		
						.490	5.627	0	5.543		
						.382	5.592				
						.242	5.568				
						0	5.555				

F.S. 6.271		F.S. 6.667		F.S. 7.167		F.S. 7.500		F.S. 7.917		F.S. 8.333	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	7.512	0	7.633	0	7.787	0	7.888	0	8.020	0	8.260
.120	7.503	.197	7.618	.187	7.772	.205	7.875	.175	8.008	.105	8.253
.225	7.490	.328	7.595	.330	7.752	.397	7.840	.303	7.990	.235	8.232
.417	7.447	.520	7.538	.510	7.702	.658	7.737	.455	7.953	.347	8.200
.602	7.370	.758	7.413	.723	7.600	.880	7.547	.647	7.883	.482	8.143
.785	7.250	.910	7.283	.857	7.505	1.022	7.455	.853	7.765	.588	8.080
.935	7.105	1.052	7.103	.980	7.388	1.163	7.223	.997	7.635	.692	8.020
1.063	6.898	1.132	6.928	1.067	7.880	1.233	6.997	1.158	7.455	.758	7.942
1.122	6.703	1.168	6.777	1.160	7.157	1.252	4.838	1.223	7.262	.913	7.830
1.135	6.540	1.182	6.633	1.185	7.645	Straight line		1.262	7.075	1.040	7.713
1.128	6.325	Straight line		1.217	6.888	1.252	6.697	1.273	6.938	1.168	7.553
1.087	6.125	1.182	6.582	1.230	6.755	1.238	6.485	Straight line		1.265	7.347
.993	5.918	1.177	6.425	Straight line		1.220	6.370	1.273	6.742	1.302	7.187
.870	5.780	1.152	6.250	1.230	6.655	1.178	6.237	1.263	6.617	1.312	7.033
.748	5.703	1.082	6.052	1.225	6.468	1.077	6.047	1.233	6.440	Straight line	
.482	5.622	.922	5.908	1.188	6.290	.922	5.897	1.167	6.250	1.312	6.763
.278	5.588	.872	5.802	1.125	6.117	.848	5.850	1.077	6.095	1.292	6.553
0	5.578	.728	5.722	1.025	5.962	.742	5.800	.995	5.958	1.232	6.338
		.558	5.667	.915	5.860	.563	5.745	.817	5.863	1.130	6.147
		.367	5.632	.780	5.778	.353	5.705	.627	5.786	.978	5.982
		.237	5.622	.610	5.717	.200	5.688	.420	5.738	.790	5.862
		.088	5.613	.343	5.670	Straight line		.243	5.723	.630	5.797
		Straight line		.153	5.658	0	5.688	Straight line		.475	5.763
		0	5.613	Straight line				0	5.723	.278	5.750
				0	5.658					Straight line	
										0	5.750

*B_{66} configuration aft of F.S. 8.333 is same as B_{64} configuration.

(d) Configuration B_{67} (origin at F.S. 2.375, W.L. 6.273; nose radius of 0.063)*

F.S. 2.625		F.S. 2.917		F.S. 3.333		F.S. 3.750		F.S. 4.167		F.S. 4.583	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	6.427	0	6.546	0	6.702	0	6.850	0	6.986	0	7.119
.033	6.422	.036	6.544	.051	6.699	.058	6.847	.067	6.983	.084	7.114
.065	6.410	.075	6.536	.098	6.692	.117	6.838	.141	6.975	.166	7.103
.095	6.390	.113	6.523	.145	6.680	.177	6.825	.215	6.960	.241	7.085
.119	6.360	.147	6.503	.191	6.661	.237	6.803	.293	6.935	.322	7.061
.136	6.327	.181	6.476	.239	6.635	.299	6.775	.363	6.901	.398	7.028
.142	6.288	.210	6.441	.283	6.599	.364	6.728	.424	6.863	.490	6.974
.136	6.245	.231	6.401	.319	6.559	.423	6.668	.483	6.813	.571	6.909
.119	6.211	.244	6.368	.349	6.510	.471	6.593	.543	6.742	.648	6.819
.095	6.181	.248	6.348	.373	6.447	.504	6.500	.589	6.661	.703	6.727
.065	6.161	.251	6.315	.384	6.391	.519	6.412	.623	6.568	.748	6.603
.033	6.148	.248	6.275	.389	6.331	.521	6.366	.638	6.492	.768	6.489
0	6.144	.244	6.248	.384	6.274	.518	6.313	.646	6.417	.773	6.393
		.231	6.208	.373	6.216	.512	6.261	.644	6.342	.768	6.293
		.210	6.169	.349	6.153	.504	6.213	.638	6.267	.748	6.167
		.181	6.133	.319	6.101	.471	6.113	.623	6.175	.703	6.029
		.147	6.106	.283	6.061	.423	6.033	.589	6.080	.648	5.937
		.113	6.085	.239	6.024	.364	5.969	.543	5.996	.571	5.858
		.075	6.070	.191	5.994	.299	5.924	.483	5.925	.490	5.803
		.036	6.063	.145	5.976	.237	5.896	.424	5.878	.398	5.759
		0	6.061	.098	5.962	.176	5.877	.363	5.842	.322	5.734
				.051	5.954	.117	5.866	.293	5.811	.241	5.718
				0	5.951	.058	5.859	.215	5.789	.166	5.708
						0	5.857	.141	5.777	.084	5.703
								.067	5.772	0	5.702
								0	5.770		

*B_{67} configuration aft of F.S. 4.583 is same as B_{64} configuration.

TABLE II.- BUTTOCK-LINE AND WATER-LINE ORDINATES AT VARIOUS FUSELAGE STATIONS

FOR DIFFERENT CONFIGURATIONS – Continued

(e) Configuration B_{68} (origin at F.S. 2.692, W.L. 6.207; nose radius of 0.067)*

F.S. 3.333		F.S. 3.750		F.S. 4.167		F.S. 4.583		F.S. 5.000		F.S. 5.427	
r	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0.350	6.257	0	6.768	0	6.908	0	7.037	0	7.160	0	7.275
		.112	6.755	.147	6.895	.163	7.020	.163	7.147	.207	7.258
		.202	6.732	.252	6.870	.312	6.983	.327	7.105	.353	7.220
		.292	6.688	.380	6.812	.432	6.933	.528	7.010	.542	7.140
		.367	6.635	.487	6.727	.570	6.837	.667	6.905	.708	7.022
		.423	6.568	.567	6.620	.673	6.717	.797	6.742	.830	6.890
		.463	6.497	.612	6.517	.738	6.570	.853	6.603	.952	6.647
		.495	6.403	.637	6.415	.763	6.445	.892	6.372	.992	6.407
		.508	6.287	.647	6.317	.775	6.345	.885	6.183	.982	6.208
		.500	6.168	.642	6.218	.772	6.205	.837	5.990	.943	6.023
		.468	6.067	.622	6.100	.745	6.053	.743	5.825	.862	5.855
		.423	5.988	.572	5.972	.675	5.892	.593	5.697	.768	5.745
		.375	5.927	.495	5.870	.563	5.772	.427	5.642	.630	5.658
		.303	5.868	.383	5.780	.407	5.680	.235	5.605	.455	5.595
		.207	5.822	.313	5.747	.253	5.640	0	5.595	.363	5.577
		.113	5.797	.203	5.713	0	5.625			.215	5.558
		0	5.788	0	5.695					0	5.547

F.S. 5.833		F.S. 6.271		F.S. 6.667		F.S. 7.167		F.S. 7.500		F.S. 7.917	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	7.358	0	7.502	0	7.607	0	7.755	0	7.868	0	8.035
.107	7.380	.202	7.487	.213	7.595	.205	7.745	.217	7.855	.208	8.013
.215	7.367	.387	7.450	.417	7.548	.370	7.723	.375	7.830	.417	7.962
.370	7.328	.528	7.403	.640	7.453	.575	7.672	.542	7.788	.695	7.857
.562	7.250	.703	7.297	.830	7.327	.763	7.590	.763	7.693	.897	7.738
.720	7.147	.865	7.163	.978	7.187	.935	7.465	.938	7.578	1.052	7.588
.820	7.057	.975	7.035	1.083	7.022	1.060	7.323	1.075	7.430	1.163	7.423
.947	6.895	1.075	6.853	1.145	6.855	1.157	7.157	1.178	7.248	1.228	7.265
1.028	6.740	1.132	6.630	1.172	6.730	1.215	6.955	1.238	7.023	1.265	7.108
1.065	6.575	1.142	6.458	1.183	6.600	1.230	6.767	1.252	6.858	1.277	6.958
1.075	6.410	1.118	6.238	1.182	6.423	Straight line		Straight line		Straight line	
1.063	6.275	1.060	6.040	1.155	6.232	1.230	6.672	1.252	6.720	1.277	6.760
1.035	6.120	.962	5.870	1.095	6.050	1.227	6.527	1.247	6.595	1.267	6.568
.978	5.958	.818	5.740	.988	5.887	1.205	6.357	1.223	6.413	1.233	6.380
.887	5.820	.610	5.645	.852	5.775	1.153	6.170	1.170	6.230	1.168	6.210
.773	5.725	.435	5.602	.703	5.697	1.068	6.010	1.088	6.668	1.032	6.017
.602	5.637	.273	5.582	.463	5.625	.940	5.867	.977	5.940	.817	5.867
.420	5.587	.128	5.573	.278	5.603	.753	5.748	.850	5.838	.605	5.785
.227	5.563	0	5.567	.080	5.593	.618	5.697	.677	5.750	.383	5.785
0	5.553			Straight line		.527	5.675	.535	5.712	.245	5.717
				0	5.593	.432	5.658	.357	5.687	Straight line	
						.276	5.643	.197	5.675	0	5.717
						.150	5.633	Straight line			
						Straight line		0	5.675		
						0	5.633				

*B_{68} configuration aft of F.S. 7.917 is same as B_{64} configuration.

(f) Configuration B_{69} (origin at F.S. 2.688, W.L. 6.293; nose radius of 0.063)

F.S. 3.333		F.S. 4.167		F.S. 5.000		F.S. 5.833		F.S. 6.667		F.S. 7.167		F.S. 7.917	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	6.684	0	6.988	0	7.238	0	7.463	0	7.692	0	7.820	0	8.088
.118	6.663	.135	6.976	.150	7.229	.128	7.457	.141	7.684	.144	7.817	.125	8.078
.198	6.621	.287	6.935	.302	7.193	.260	7.436	.303	7.658	.289	7.796	.249	8.052
.271	6.554	.428	6.857	.459	7.131	.389	7.398	.468	7.606	.478	7.744	.383	8.004
.316	6.488	.518	6.767	.596	7.044	.529	7.342	.651	7.526	.684	7.654	.521	7.932
.343	6.404	.583	6.668	.701	6.950	.647	7.277	.808	7.427	.856	7.542	.813	7.803
.348	6.317	.623	6.531	.779	6.846	.749	7.200	.941	7.304	1.000	7.400	.935	7.708
.326	6.229	.640	6.454	.839	6.734	.859	7.093	1.049	7.157	1.109	7.248		
.299	6.158	.642	6.335	.875	6.611	.947	6.972	1.123	7.003	1.191	7.061		
.249	6.093	.624	6.211	.889	6.490	1.013	6.843	1.165	6.853	1.224	6.871		
.168	6.029	.588	6.092	.888	6.363	1.055	6.696	1.182	6.667	1.228	6.683		
.103	6.001	.533	6.000	.875	6.227	1.071	6.531	1.178	6.508	1.215	6.499		
0	5.987	.449	5.909	.849	6.108	1.063	6.368	1.168	6.346	1.182	6.325		
		.343	5.842	.813	6.003	1.038	6.209	1.118	6.194	1.123	6.175		
		.218	5.797	.744	5.909	.993	6.068	1.053	6.050	1.038	6.038		
		.110	5.780	.652	5.819	.925	5.949	.953	5.929	.917	5.918		
		0	5.776	.536	5.751	.838	5.856	.819	5.833	.756	5.819		
				.408	5.703	.718	5.770	.658	5.758	.566	5.750		
				.278	5.677	.573	5.708	.475	5.707	.379	5.717		
				.141	5.663	.414	5.668	.273	5.683	.168	5.703		
				0	5.660	.208	5.646	.144	5.678	0	5.701		
						.138	5.638	0	5.673				
						0	5.634						

TABLE II.- BUTTOCK-LINE AND WATER-LINE ORDINATES AT VARIOUS FUSELAGE STATIONS

FOR DIFFERENT CONFIGURATIONS – Concluded

(f) Configuration B_{69} (origin at F.S. 2.688, W.L. 6.293; nose radius of 0.063) – Concluded

F.S. 8.333		F.S. 8.750		F.S. 9.167		F.S. 9.583		F.S. 10.000		F.S. 10.417		F.S. 10.833	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	8.293	0	8.503	0	8.707	0	8.915	0	9.093	0	9.220	0	9.305
.172	8.278	.161	8.491	.194	8.696	.207	8.903	.188	9.078	.174	9.208	.193	9.293
.314	8.243	.318	8.458	.362	8.656	.379	8.863	.367	9.034	.343	9.168	.368	9.253
.465	8.182	.475	8.396	.529	8.583	.542	8.797	.531	8.969	.500	9.120	.531	9.191
.601	8.103	.637	8.303	.708	8.463	.694	8.701	.681	8.883	.648	9.040	.688	9.114
.723	8.003	.784	8.173	.848	8.328	.837	8.583	.826	8.770	.803	8.932	.837	9.009
.845	7.864	.894	8.043	.946	8.199	.951	8.450	.954	8.638	.962	8.767	.995	8.857
.946	7.797	.988	7.889	1.018	8.073	1.043	8.293	1.062	8.489	1.094	8.615	1.105	8.698
1.044	7.708	1.073	7.810	1.081	7.939	1.102	8.151	1.154	8.298	1.162	8.497	1.185	8.534
		1.154	7.708	1.138	7.860	1.147	7.998	1.194	8.128	1.215	8.348	1.250	8.358
				1.183	7.792	1.196	7.913	1.272	8.074	1.246	8.203	1.297	8.189
				1.231	7.708	1.251	7.815	1.223	8.027	1.259	8.135	1.343	8.043
						1.296	7.703	1.255	7.956	1.275	8.088	1.378	7.888
								1.307	7.838	1.310	7.986	1.399	7.708
								1.345	7.708	1.347	7.873		
										1.380	7.708		

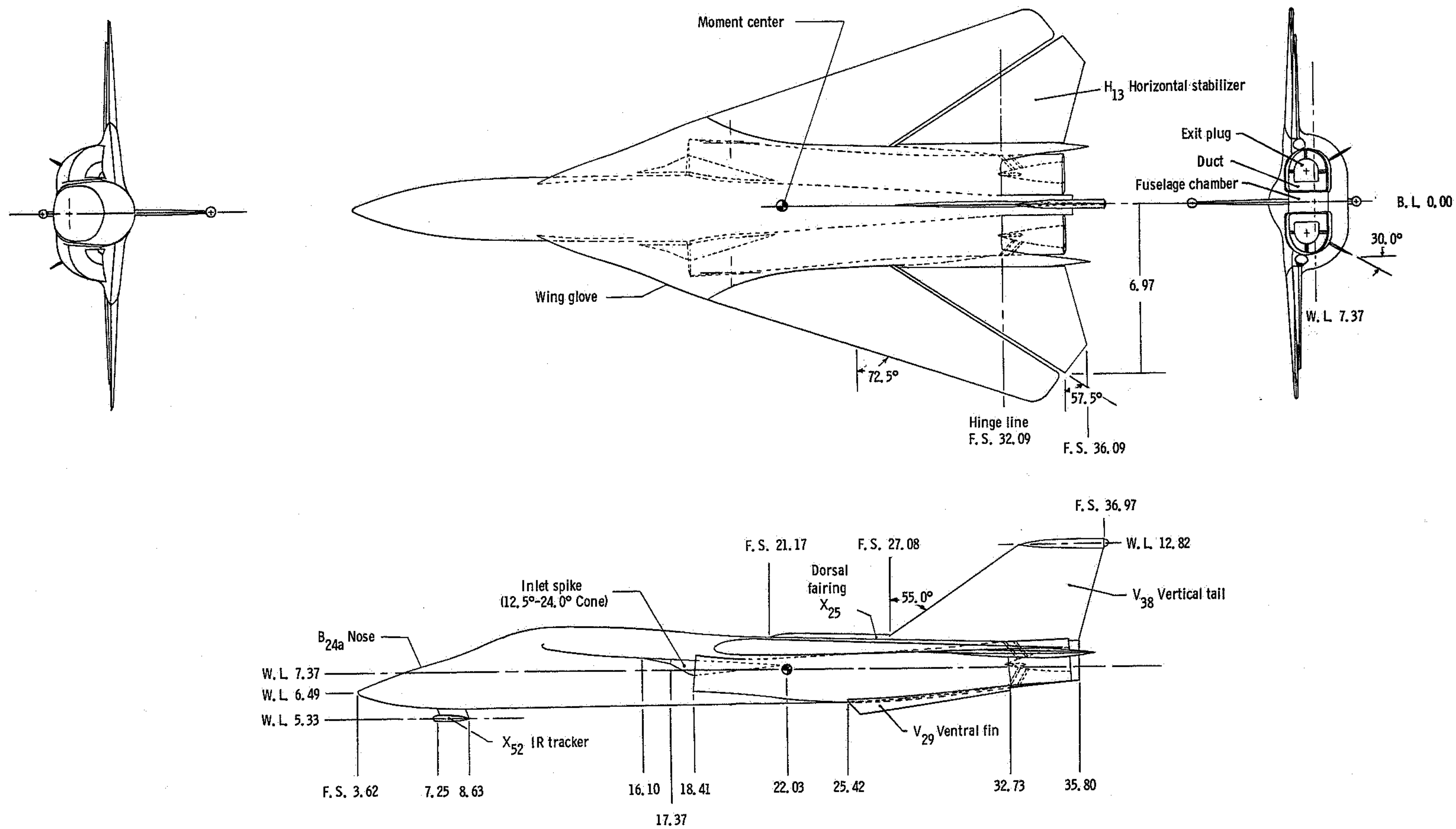
F.S. 11.250		F.S. 11.667		F.S. 12.083		F.S. 12.500		F.S. 12.967		F.S. 13.667		F.S. 14.667	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	9.367	0	9.411	0	9.430	0	9.436	0	9.430	0	9.403	0	9.345
.204	9.349	.196	9.394	.214	9.407	.237	9.411	.215	9.410	.217	9.392	.265	9.319
.396	9.303	.375	9.355	.400	9.367	.449	9.362	.418	9.368	.426	9.352	.523	9.264
.579	9.233	.543	9.295	.554	9.317	.659	9.283	.585	9.313	.630	9.282	.744	9.184
.739	9.033	.708	9.216	.713	9.241	.843	9.176	.771	9.222	.833	9.179	.958	9.082
.892	9.142	.867	9.112	.873	9.139	1.011	9.040	.932	9.113	1.003	9.065	1.162	8.971
1.046	8.878	.996	9.003	1.017	9.017	1.138	8.890	1.072	8.993	1.144	8.945	1.347	8.885
1.158	8.703	1.120	8.852	1.117	8.895	1.224	8.758	1.198	8.849	1.260	8.855	1.567	8.807
1.258	8.485	1.218	8.681	1.196	8.766	1.279	8.697	1.286	8.764	1.362	8.797	1.780	8.730
1.331	8.267	1.292	8.506	1.263	8.638	1.332	8.659	1.379	8.708	1.563	8.712	1.999	8.638
1.383	8.065	1.359	8.326	1.276	8.619	1.457	8.595	1.523	8.642	1.786	8.605	2.177	8.554
1.407	7.913	1.393	8.163	1.291	8.608	1.573	8.477	1.652	8.570	1.991	8.422	2.358	8.404
1.419	7.708	1.418	7.970	1.361	8.571	1.614	8.477	1.739	8.464	2.033	8.422	2.400	8.404
		1.425	7.806	1.413	8.538			1.781	8.464				
				1.416	8.488								
				1.458	8.488								

(g) Configuration B_{71} (origin at F.S. 2.879, W.L. 6.211; nose radius of 0.063)*

F.S. 3.125		F.S. 3.333		F.S. 3.750		F.S. 4.167	
r	W.L.	r	W.L.	r	W.L.	r	W.L.
0.195	6.235	0.285	6.255	0.457	6.292	0.600	6.328

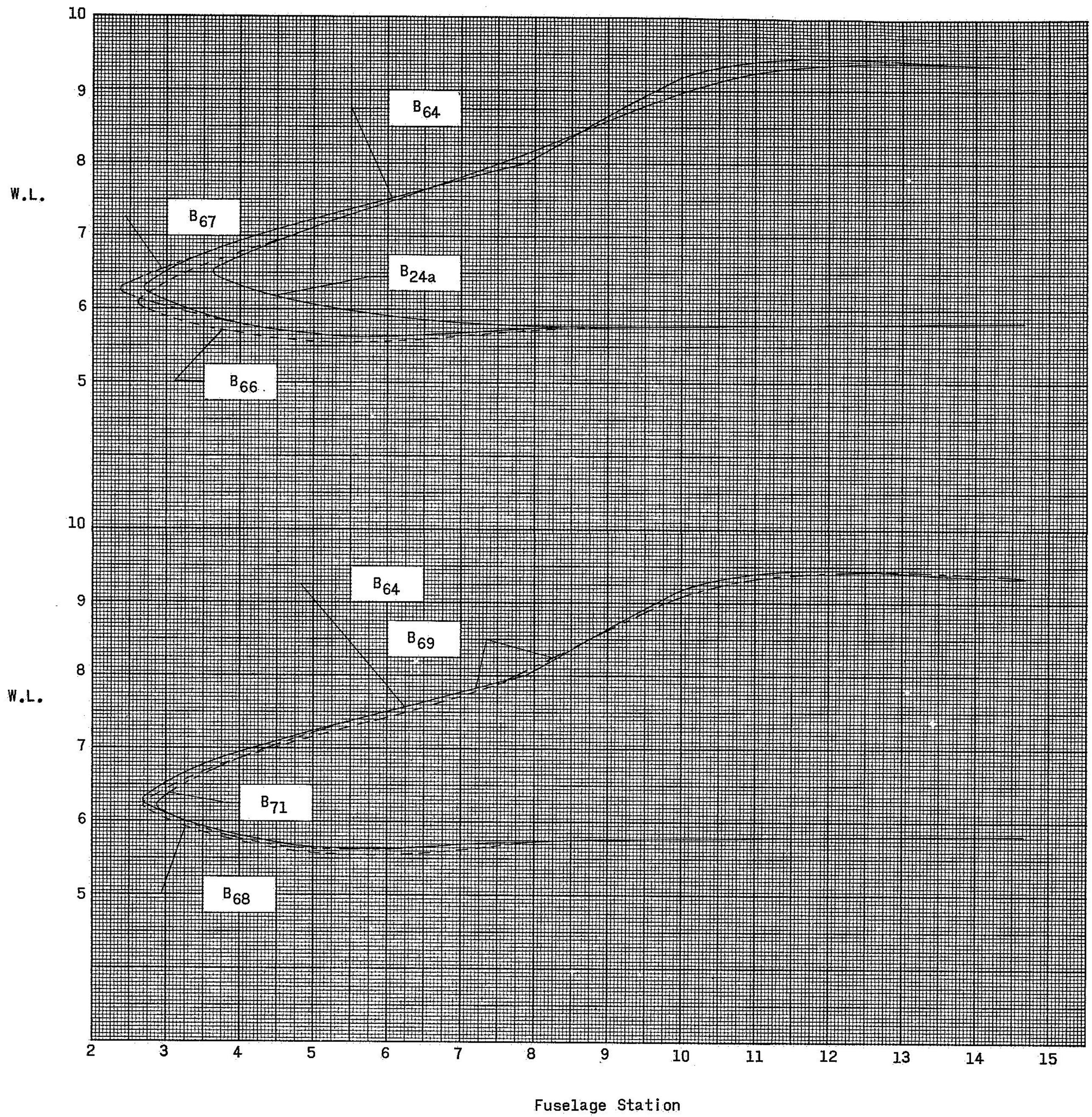
F.S. 4.583		F.S. 5.000		F.S. 5.883		F.S. 6.271	
B.L.	W.L.	B.L.	W.L.	B.L.	W.L.	B.L.	W.L.
0	7.083	0	7.217	0	7.458	0	7.587
.125	7.070	.107	7.208	.122	7.453	.157	7.575
.240	7.043	.207	7.195	.300	7.428	.338	7.543
.360	6.993	.365	7.147	.472	7.372	.526	7.473
.478	6.913	.505	7.072	.672	7.263	.715	7.380
.585	6.803	.640	6.957	.845	7.105	.920	7.198
.663	6.672	.760	6.787	.975	6.908	1.022	7.023
.712	6.520	.827	6.598	1.043	6.680	1.115	6.800
.730	6.363	.848	6.405	1.057	6.513	1.137	6.590
.705	6.180	.823	6.188	1.050	6.367	1.133	6.457
.630	5.992	.762	6.015	1.030	6.240	1.093	6.232
.507	5.838	.660	5.868	.962	6.042	1.012	6.035
.370	5.743	.512	5.747	.838	5.872	.837	5.843
.267	5.700	.330	5.663	.658	5.745	.613	5.730
.138	5.667	.178	5.632	.460	5.672	.413	5.683
0	5.657	0	5.620	.253	5.637	.220	5.660
				0	5.620	0	5.647

*B_{71} configuration aft of F.S. 6.271 is same as B_{64} configuration.



(a) Complete model.

Figure 1.- Model details. (All dimensions are in inches unless otherwise noted.)



(b) Nose and windshield details.

Figure 1.- Concluded.

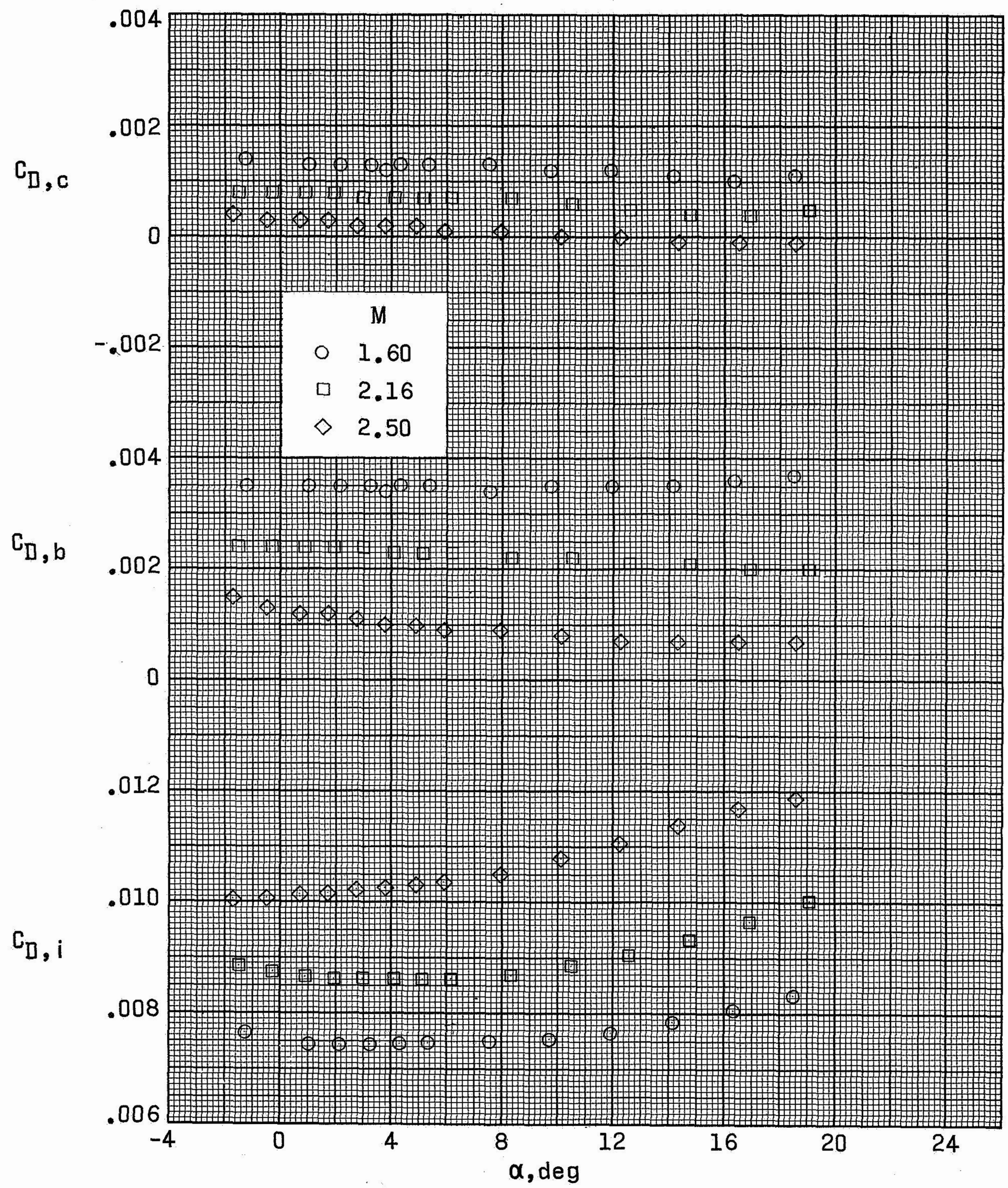
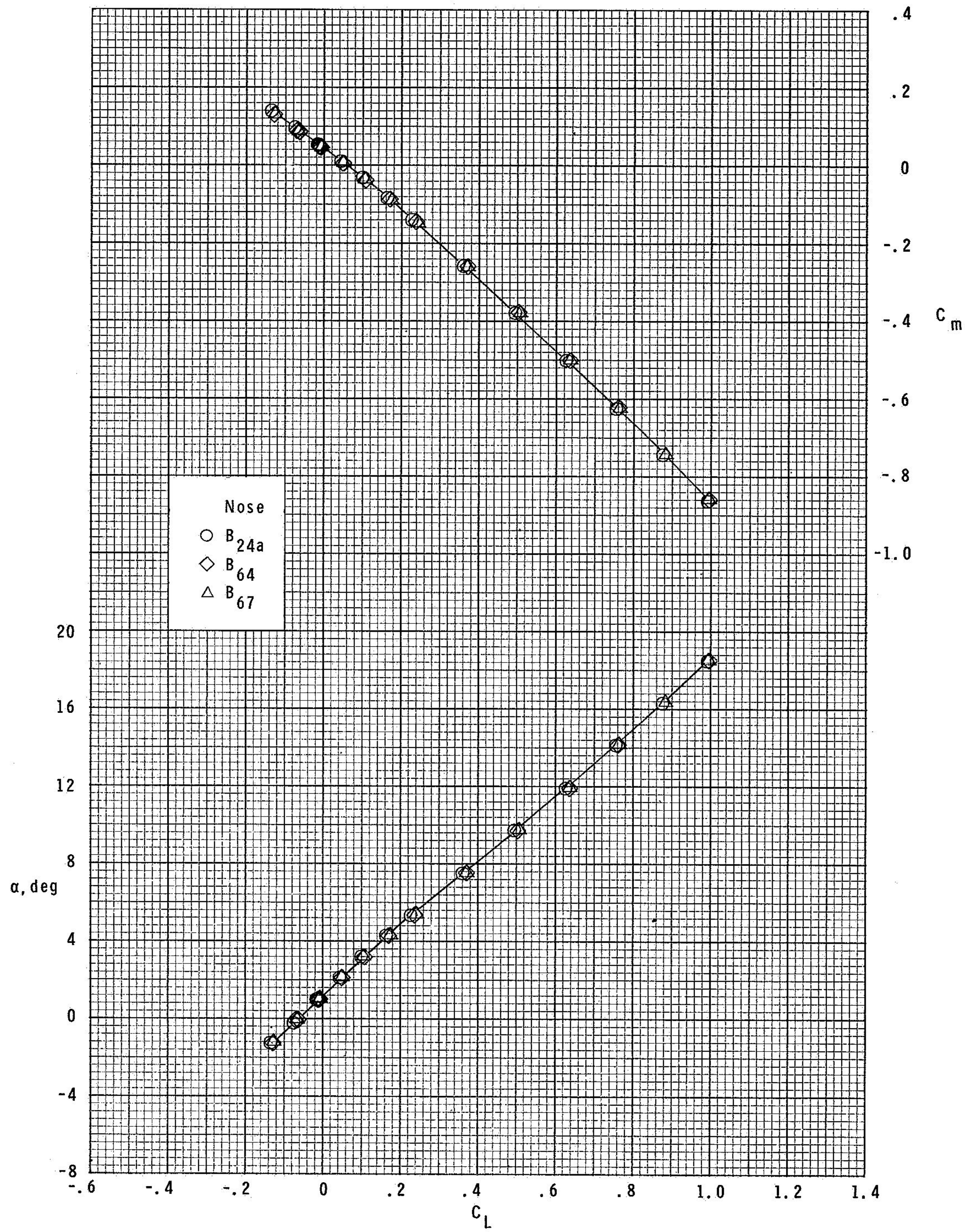
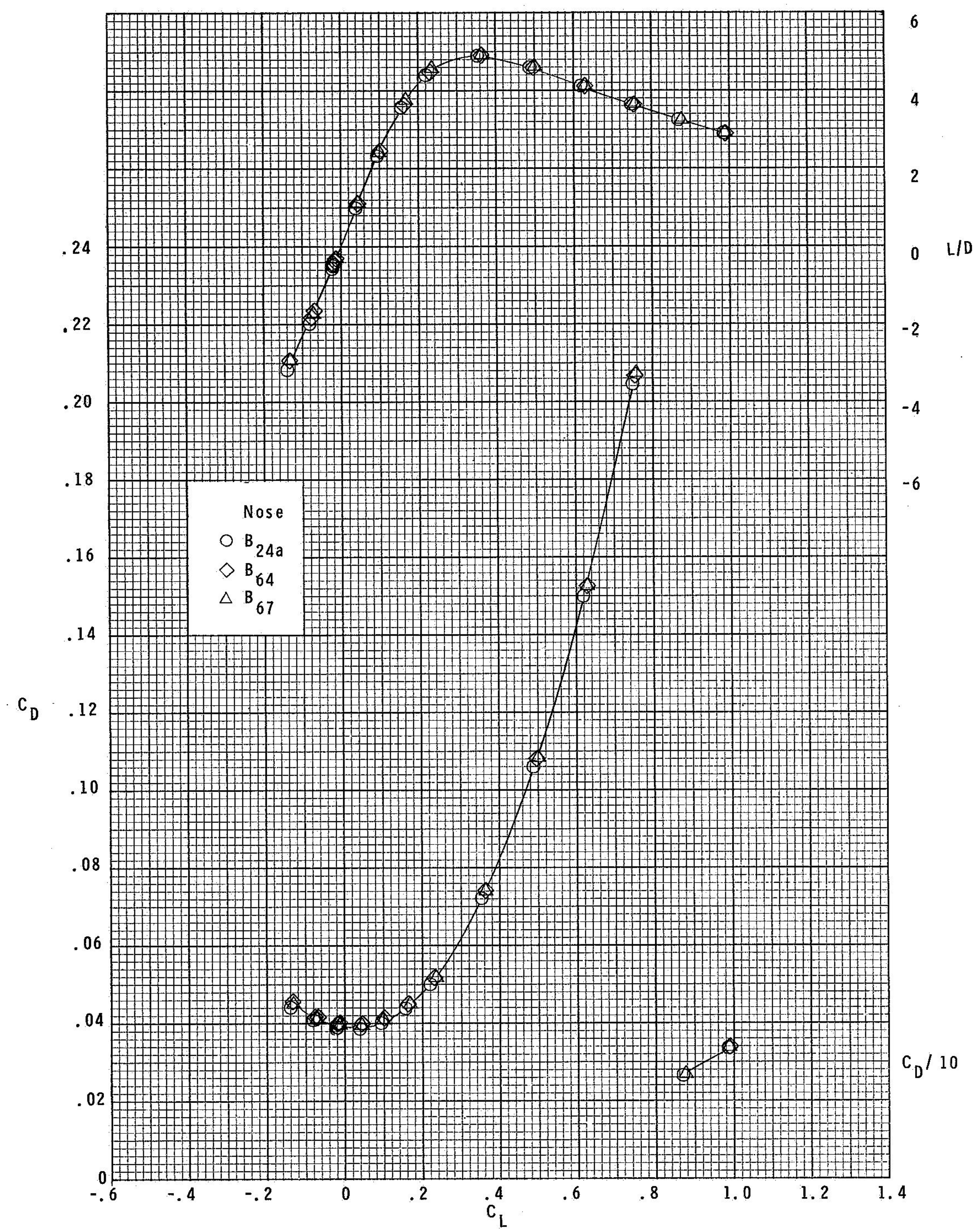


Figure 2.- Typical values of chamber-drag-coefficient, base-drag-coefficient, and internal-drag-coefficient corrections.



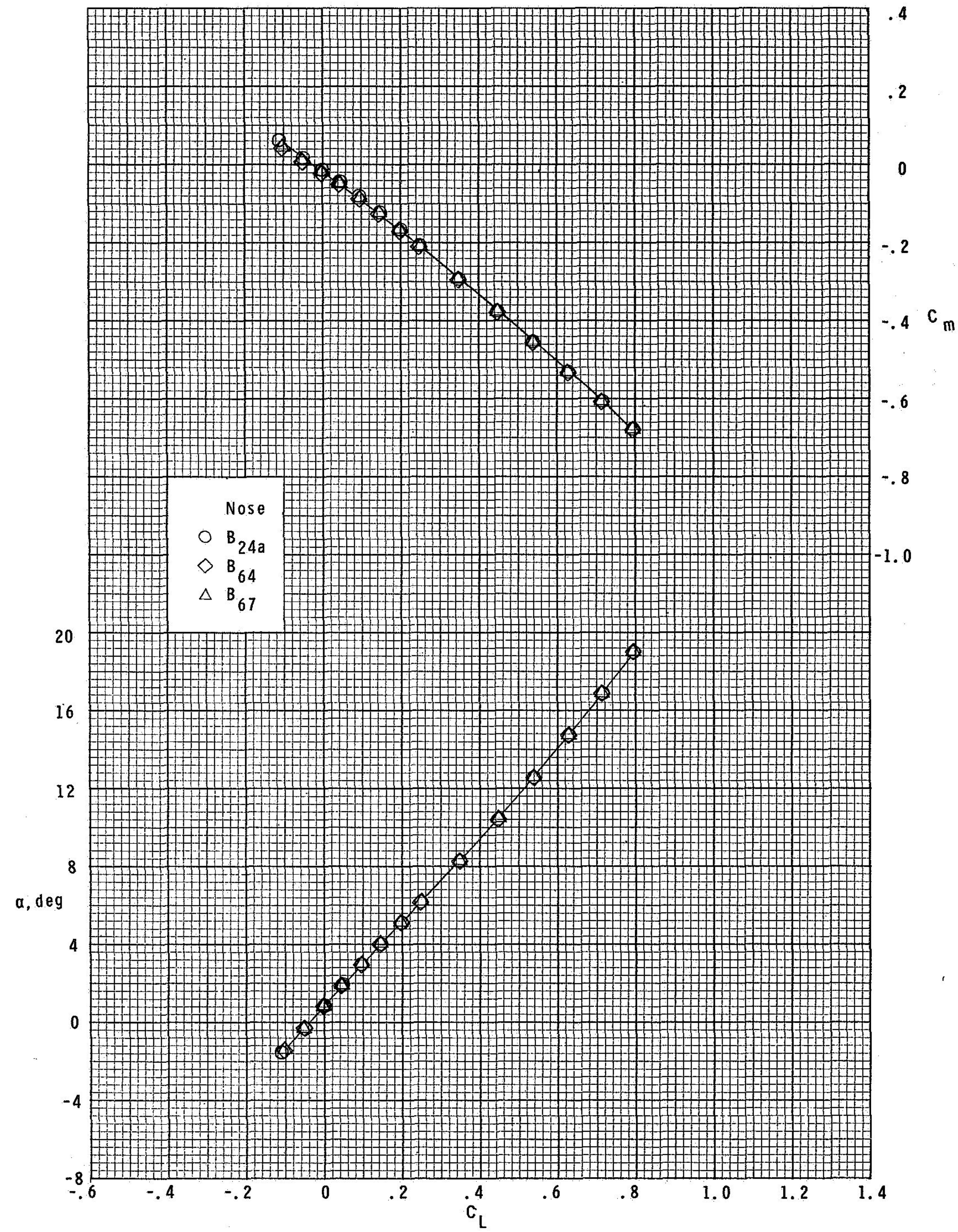
(a) M = 1.60.

Figure 3.- Effects of B_{24a}, B_{64}, and B_{67} noses on the aerodynamic characteristics in pitch.



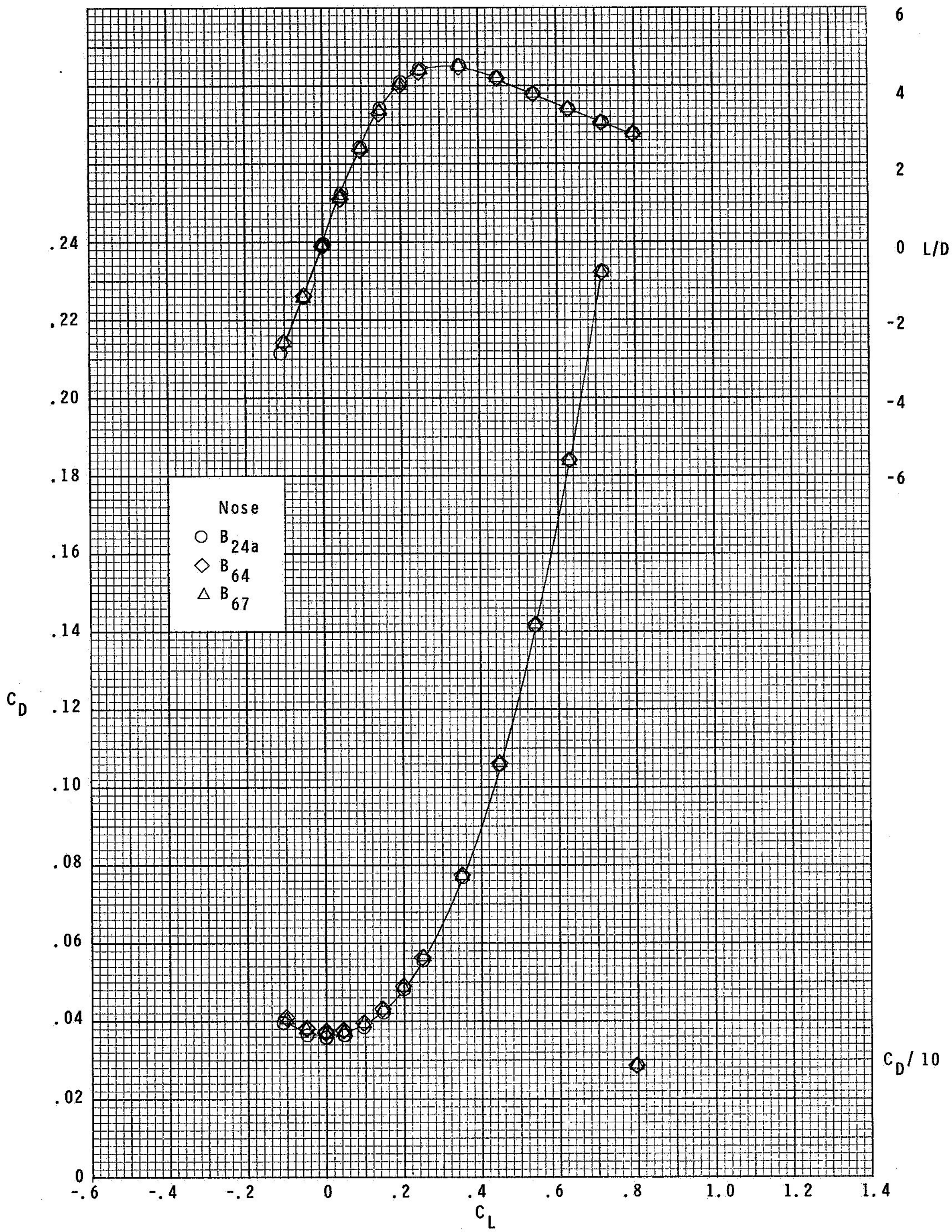
(a) Concluded.

Figure 3.- Continued.



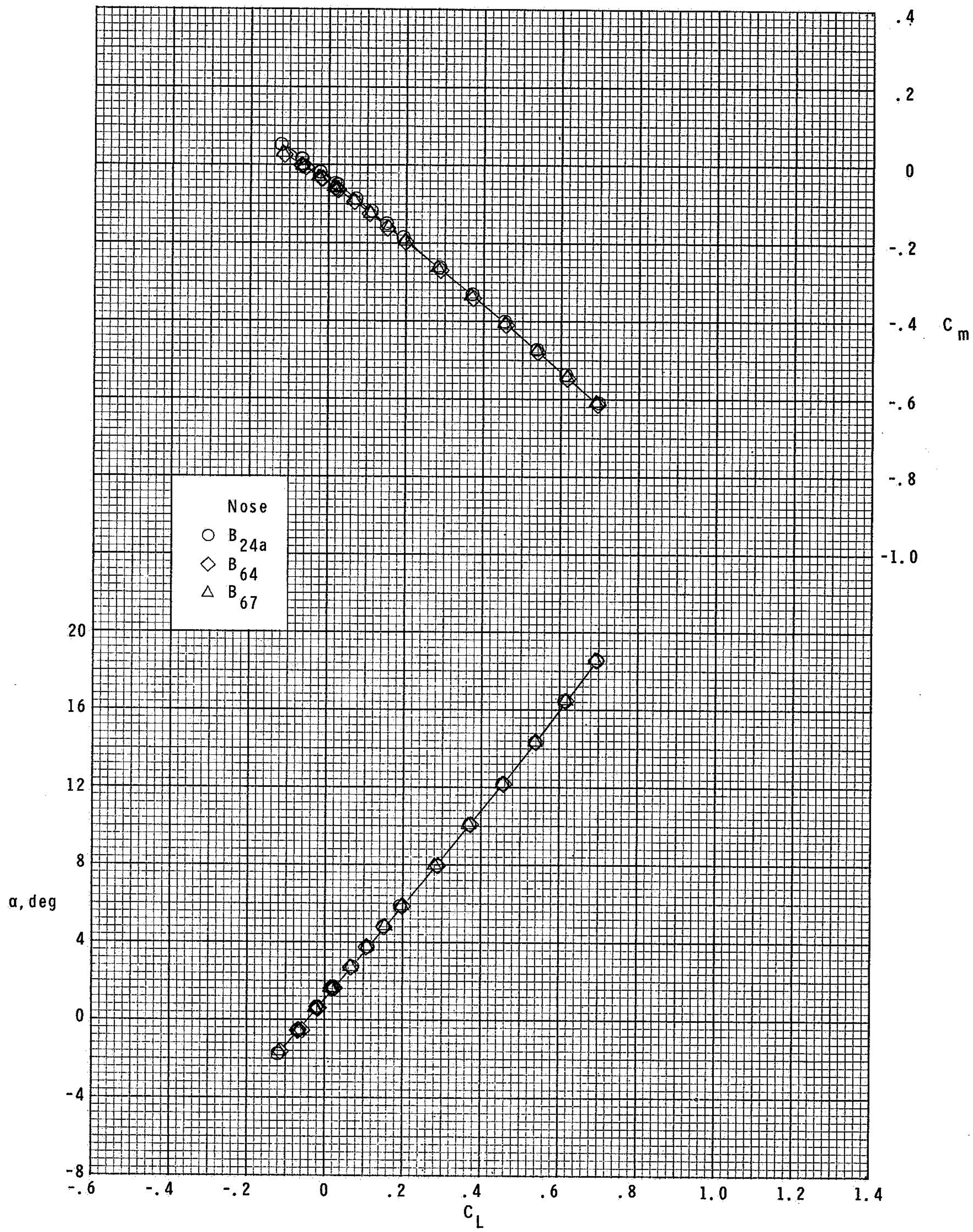
(b) M = 2.16.

Figure 3.- Continued.



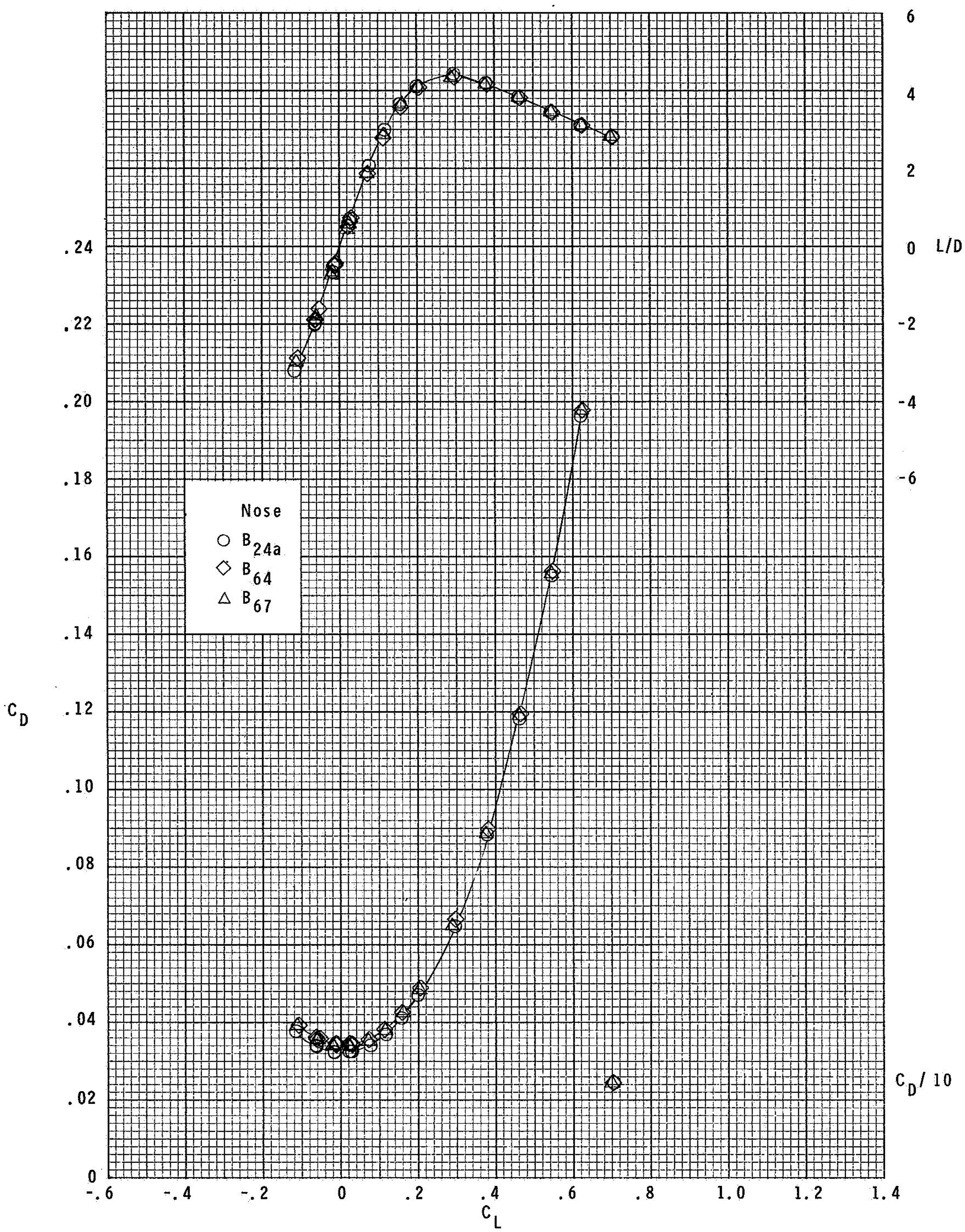
(b) Concluded.

Figure 3.- Continued.



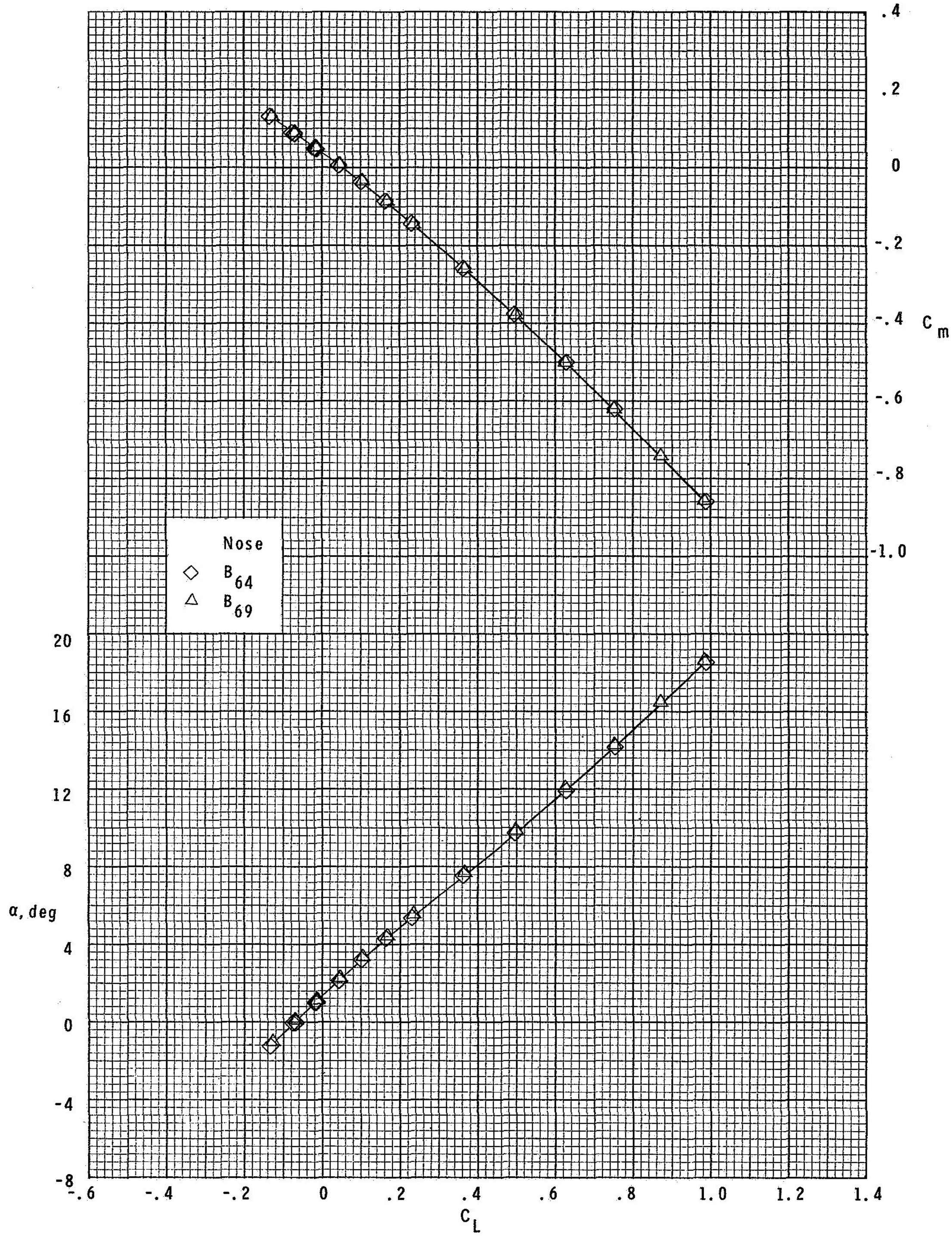
(c) M = 2.50.

Figure 3.- Continued.



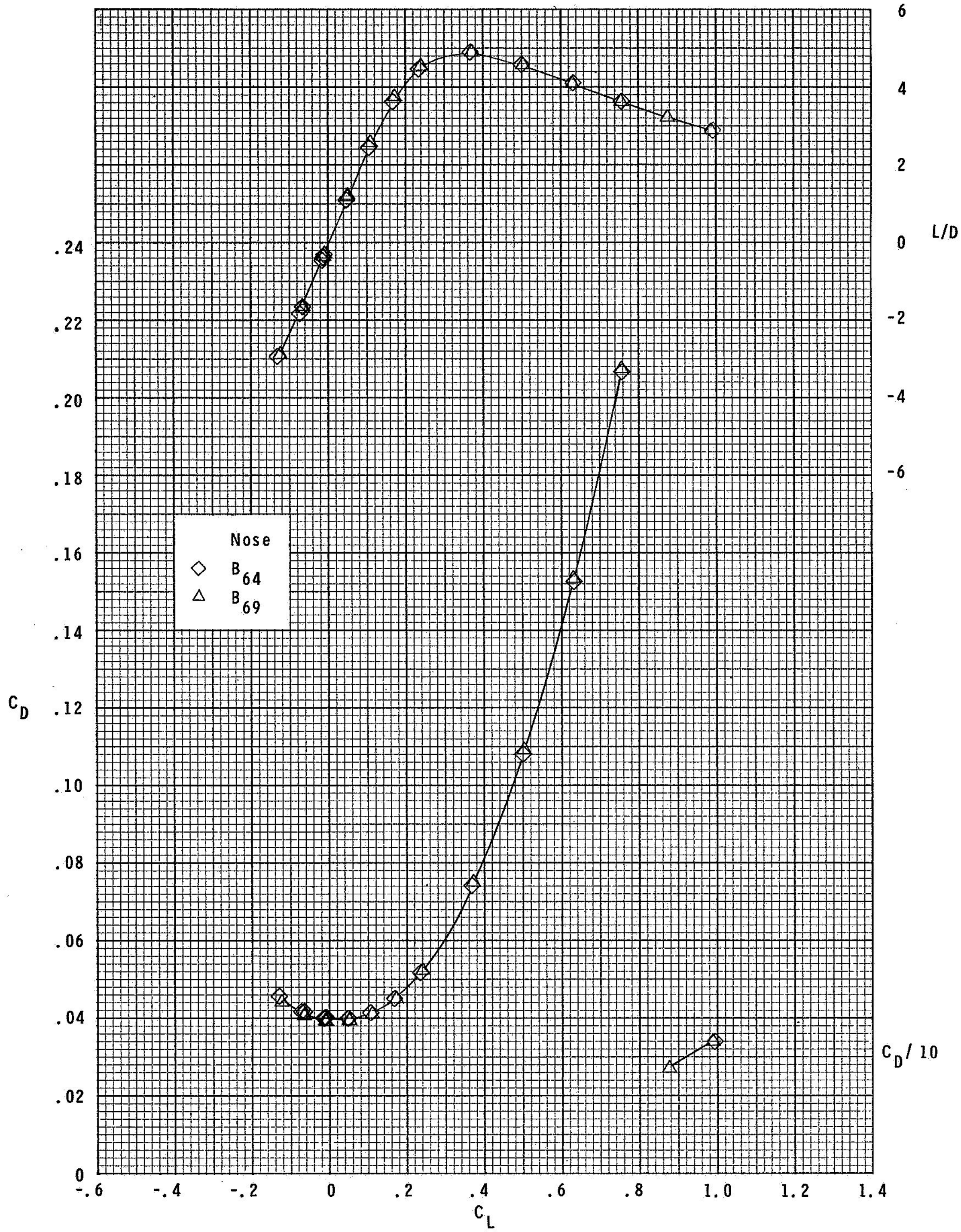
(c) Concluded.

Figure 3.- Concluded.



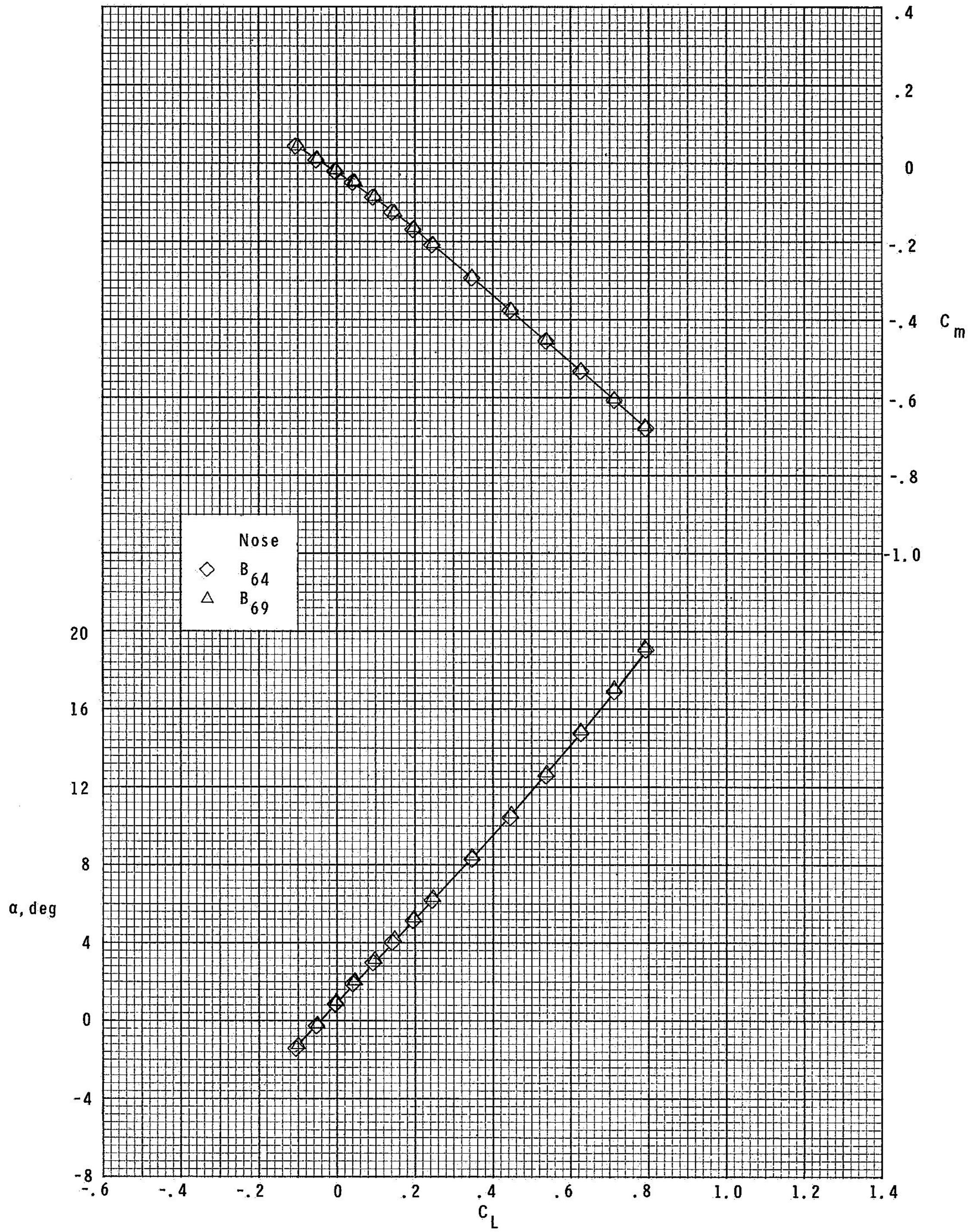
(a) M = 1.60.

Figure 4.- Effects of B_{64} and B_{69} noses on the aerodynamic characteristics in pitch.



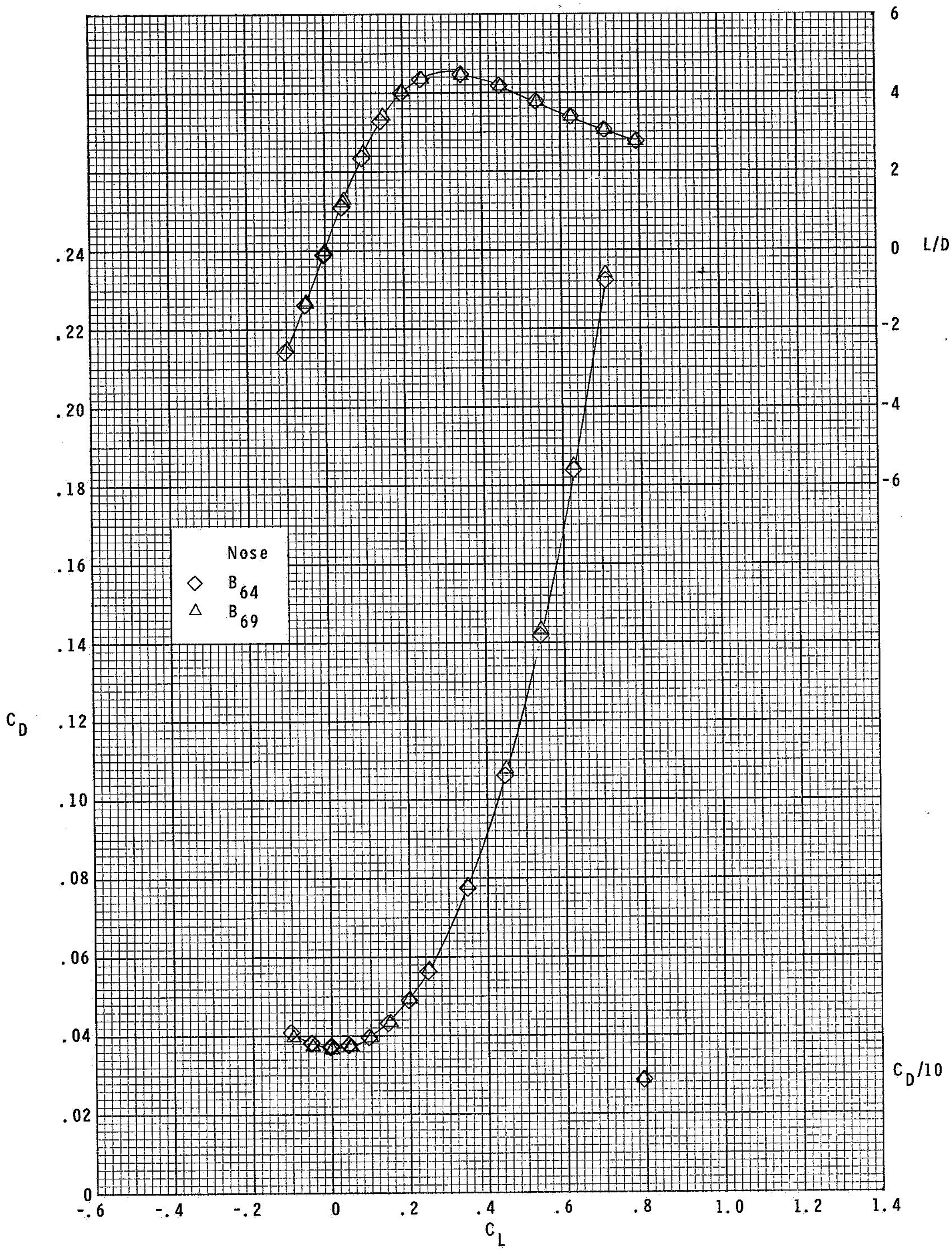
(a) Concluded.

Figure 4.- Continued.



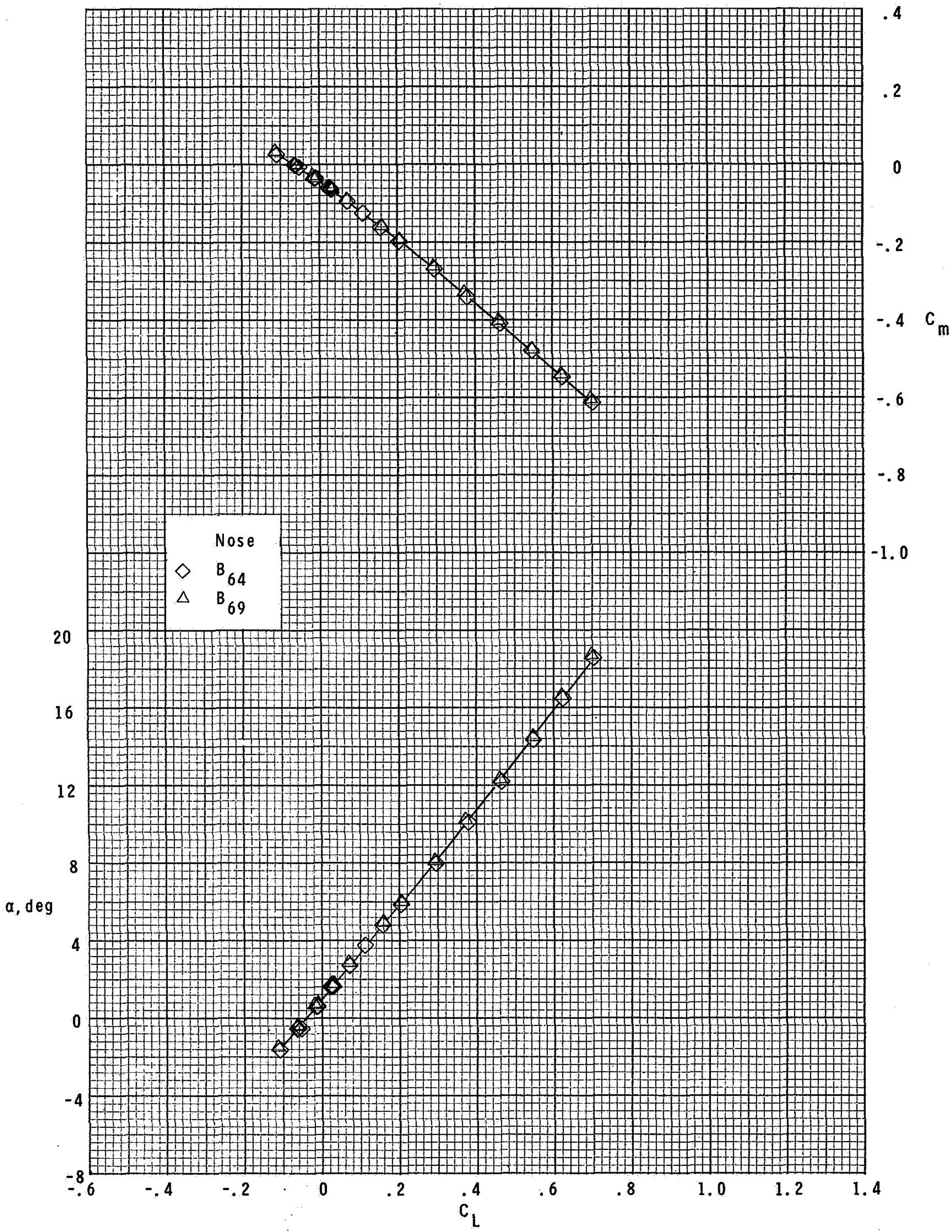
(b) $M = 2.16$.

Figure 4.- Continued.



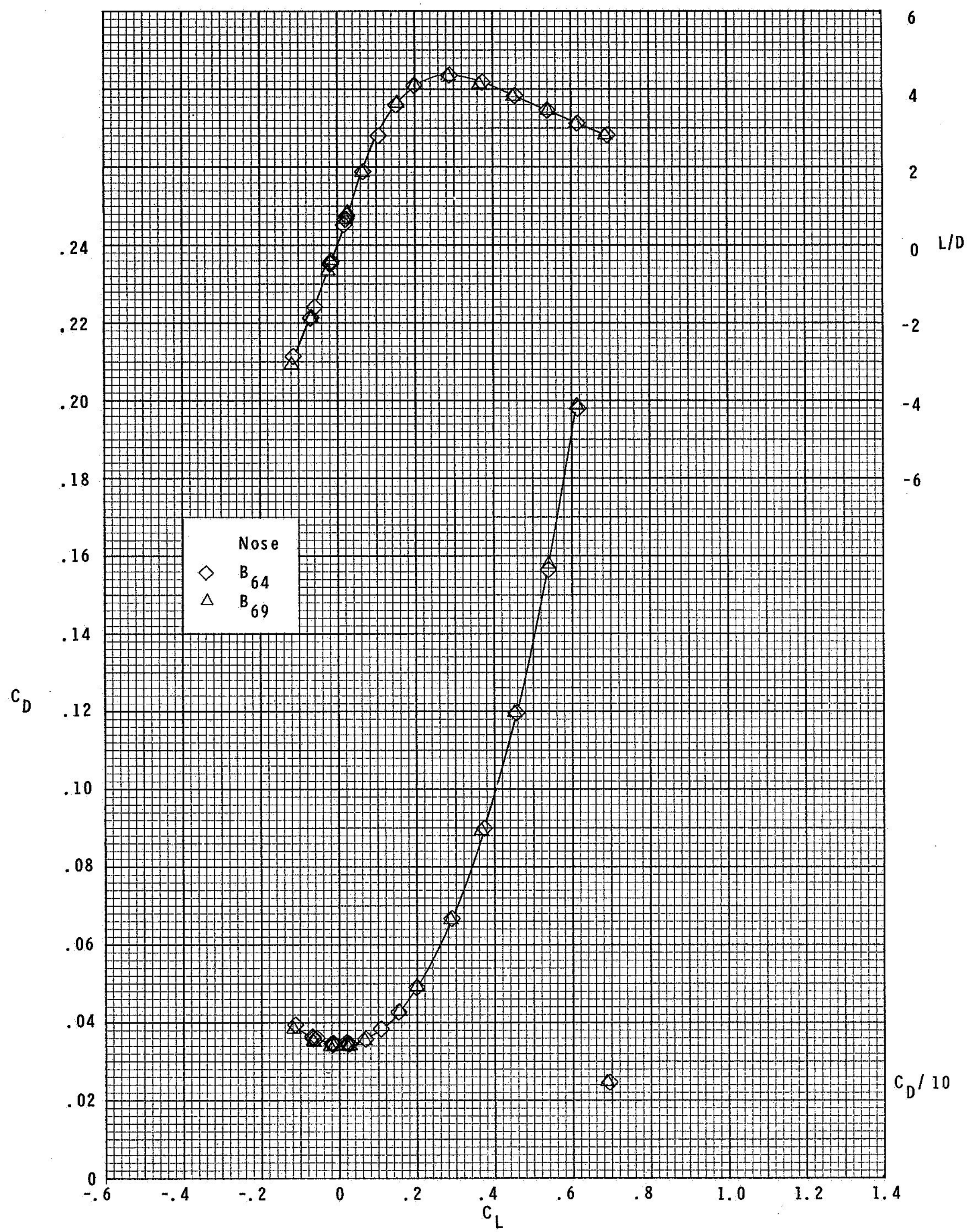
(b) Concluded.

Figure 4.- Continued.



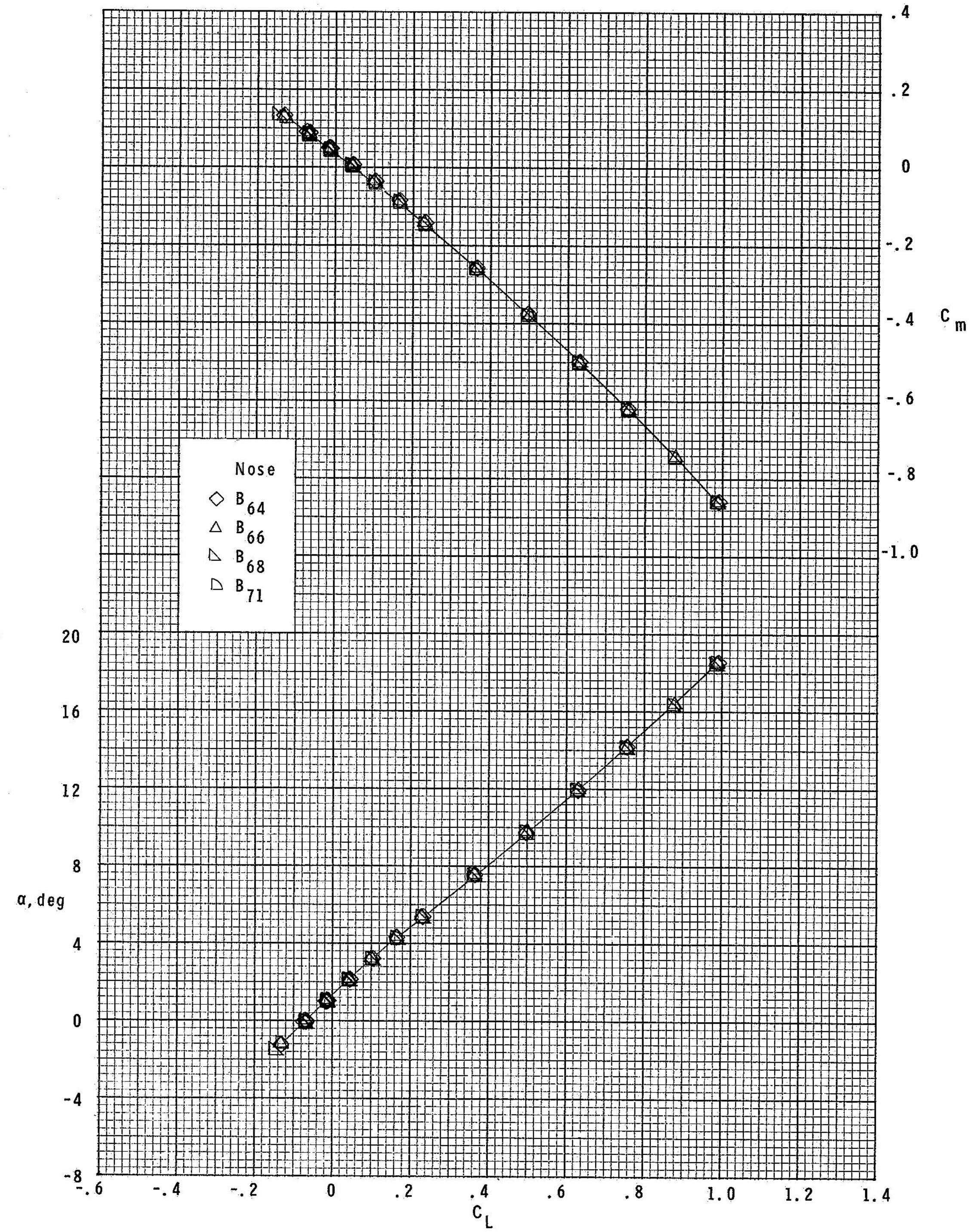
(c) M = 2.50.

Figure 4.- Continued.



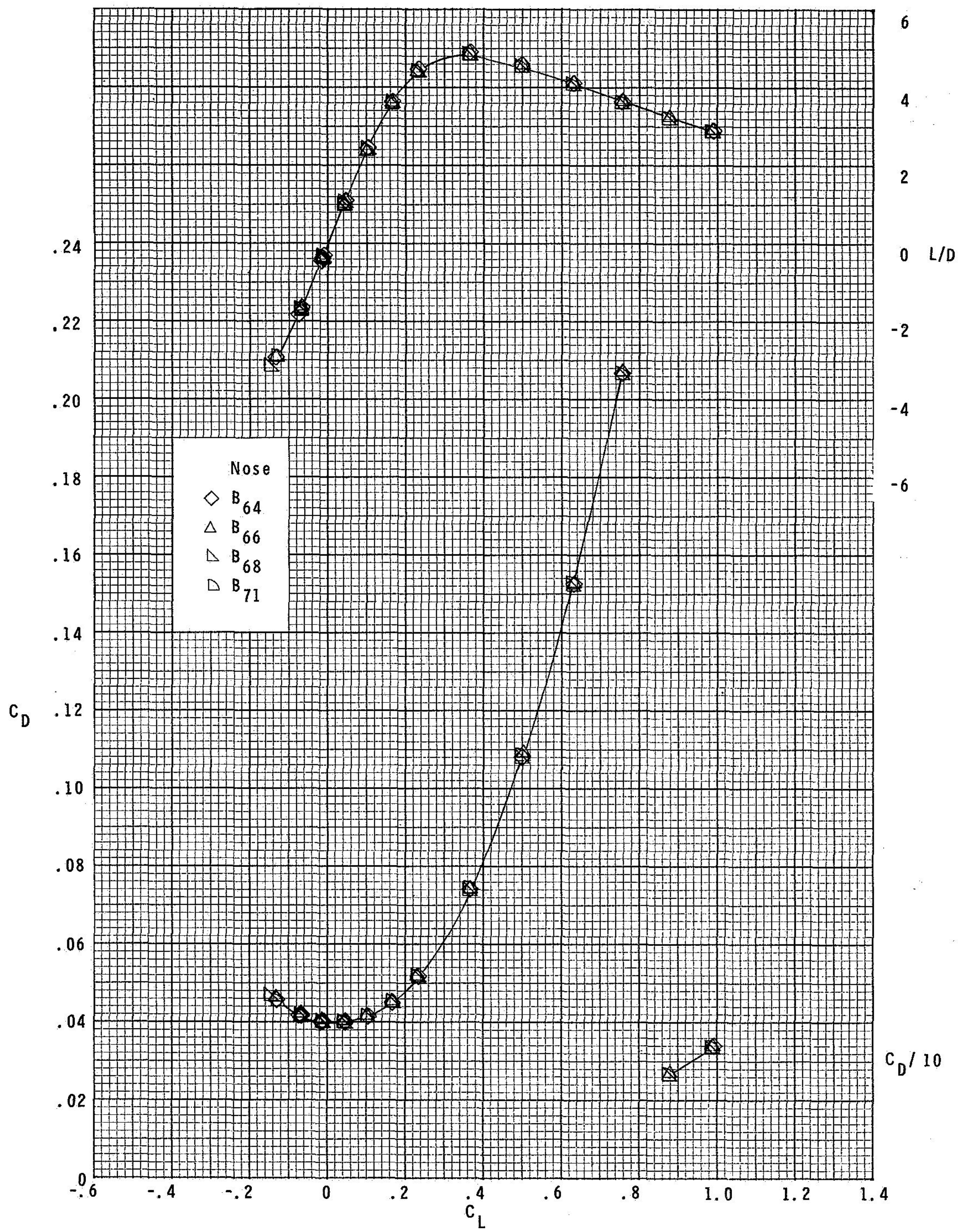
(c) Concluded.

Figure 4.- Concluded.



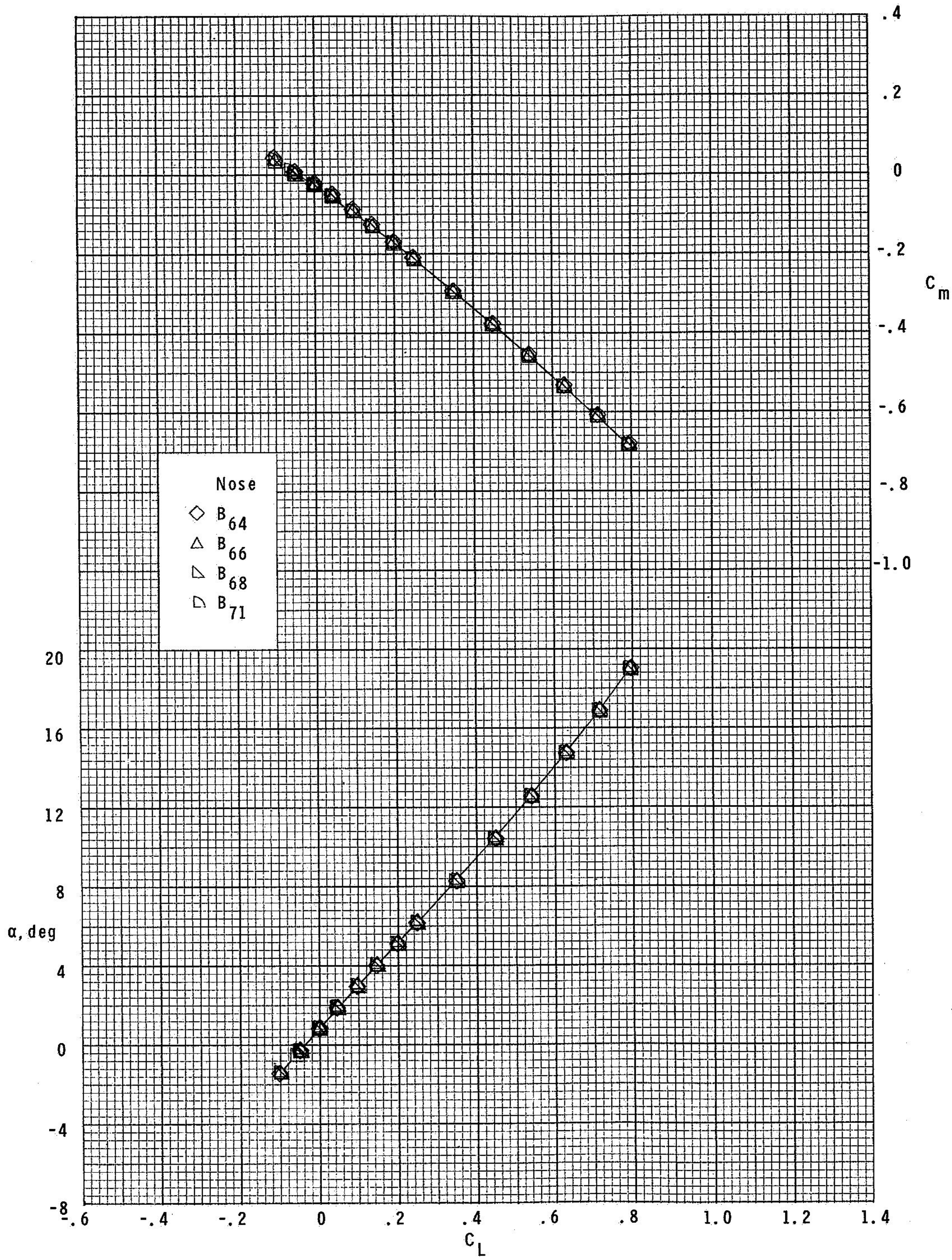
(a) M = 1.60.

Figure 5.- Effects of B_{64}, B_{66}, B_{68}, and B_{71} noses on the aerodynamic characteristics in pitch.



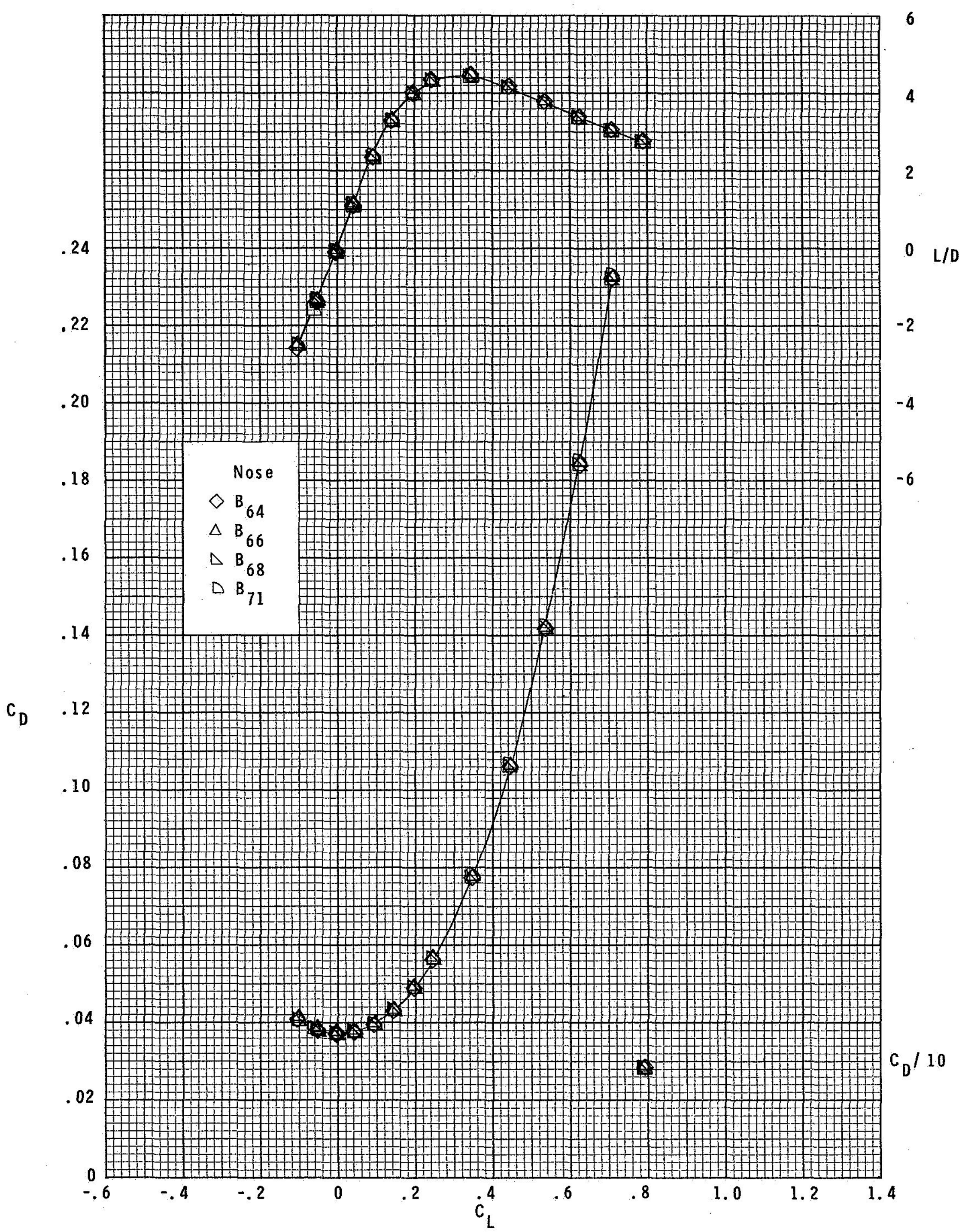
(a) Concluded.

Figure 5.- Continued.



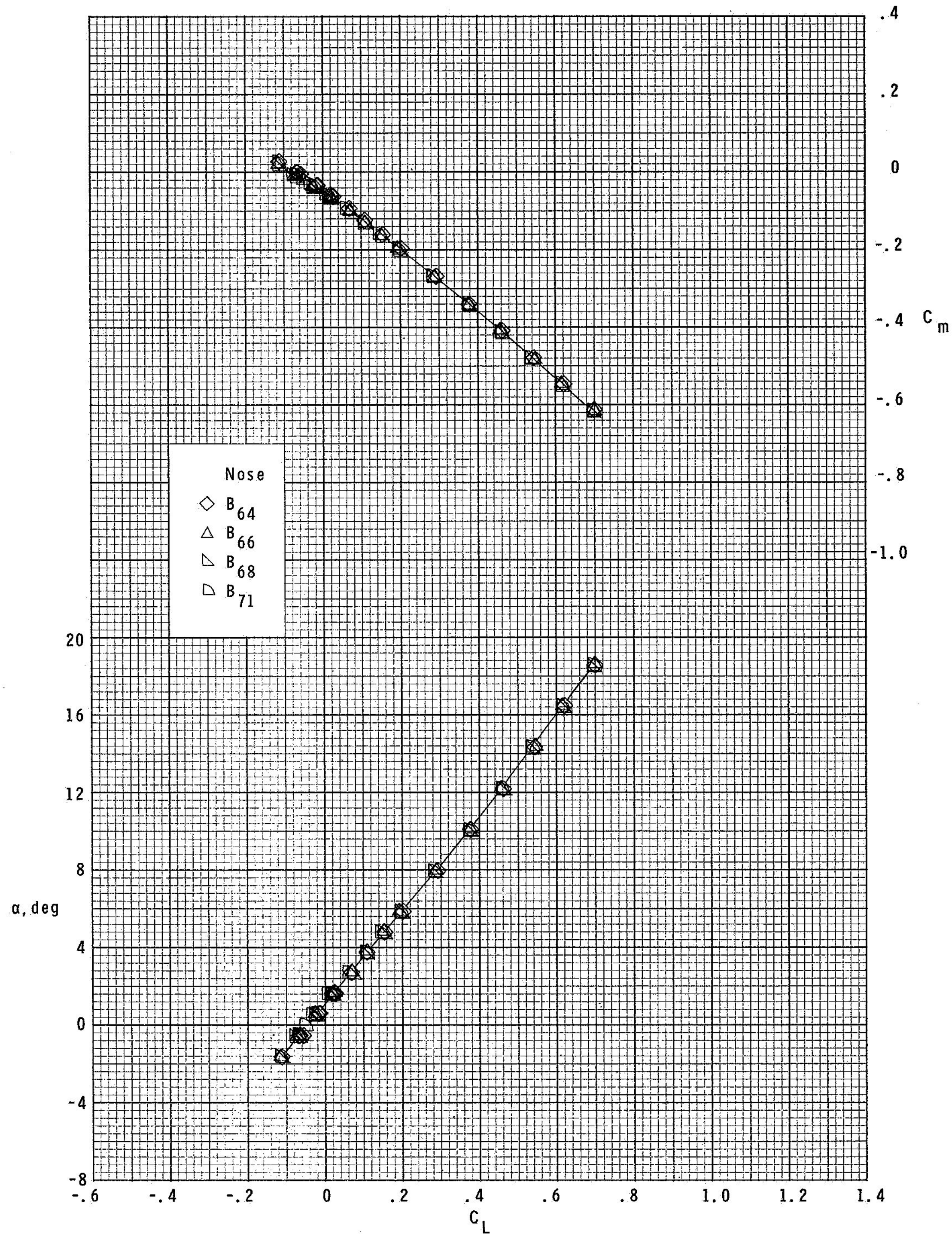
(b) M = 2.16.

Figure 5.- Continued.



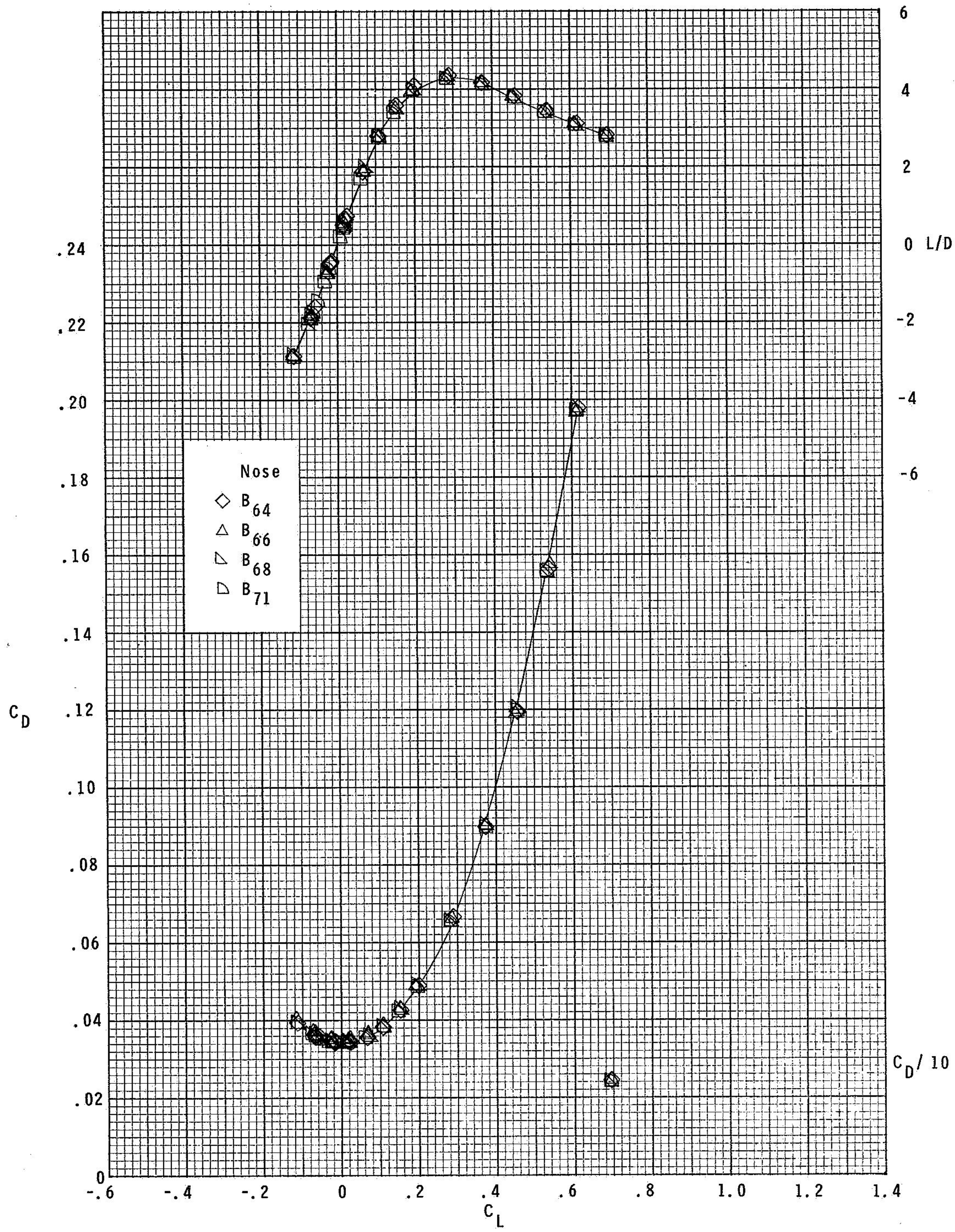
(b) Concluded.

Figure 5.- Continued.



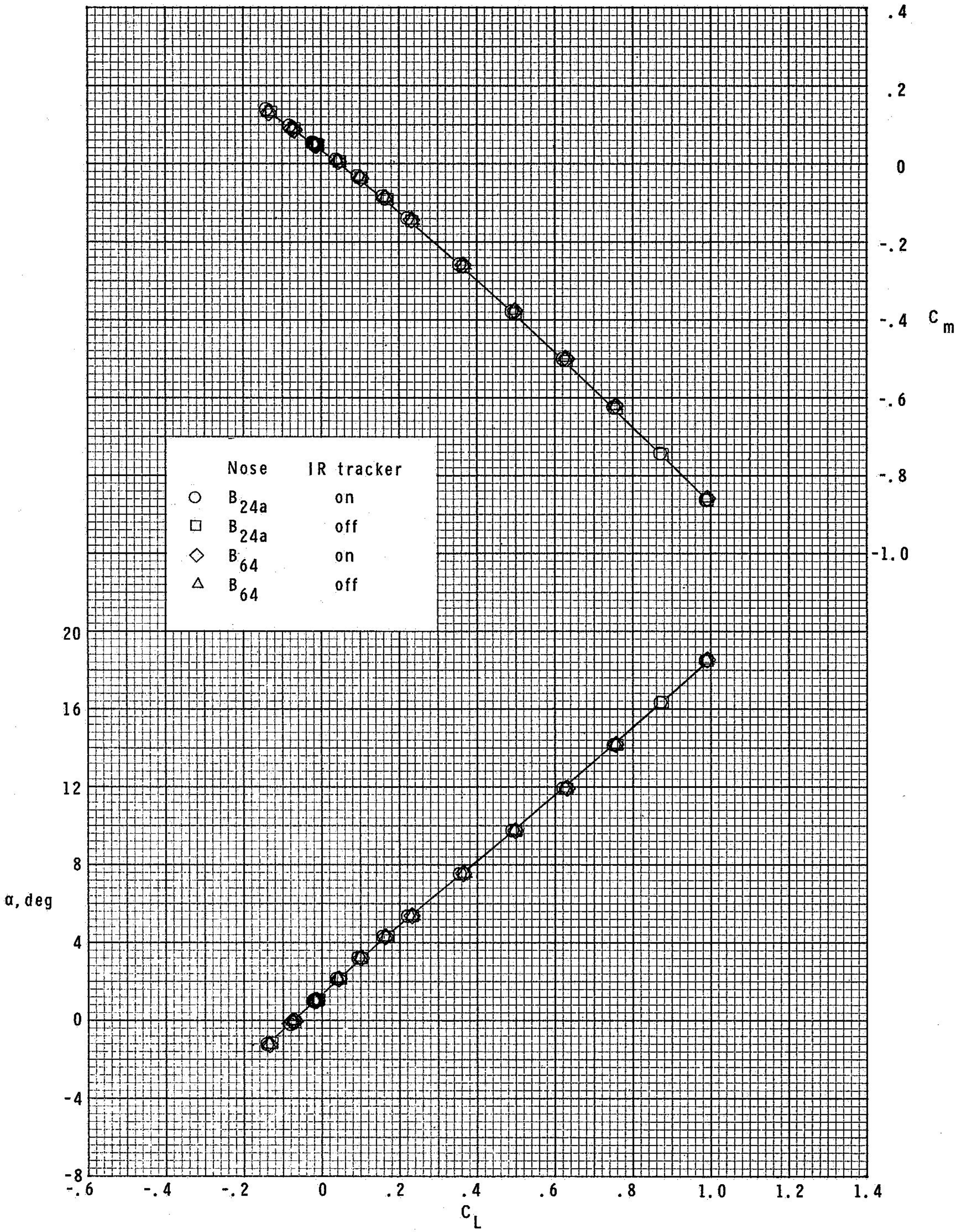
(c) M = 2.50.

Figure 5.- Continued.



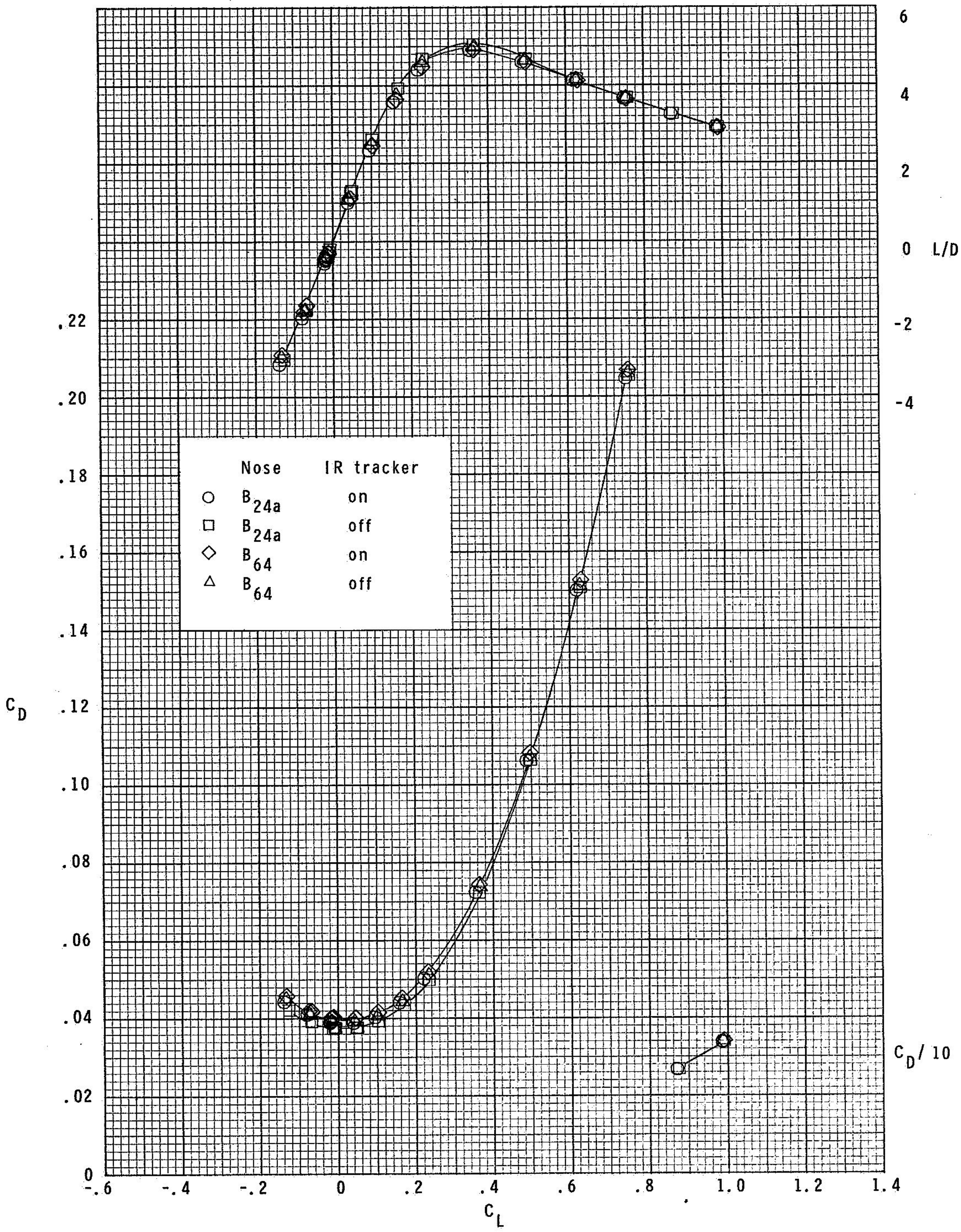
(c) Concluded.

Figure 5.- Concluded.



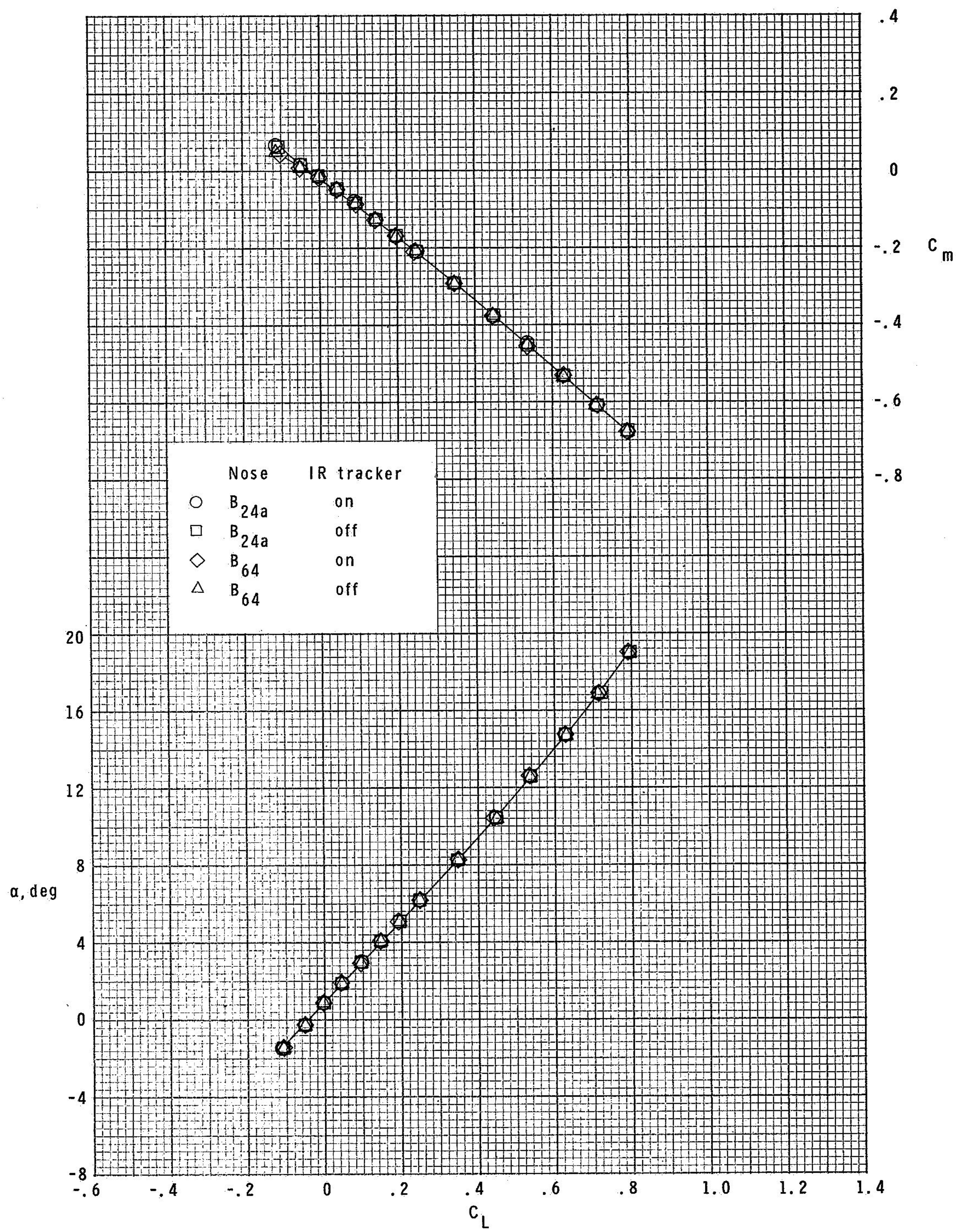
(a) M = 1.60.

Figure 6.- Effect of IR tracker (X_{52}) on the aerodynamic characteristics in pitch.



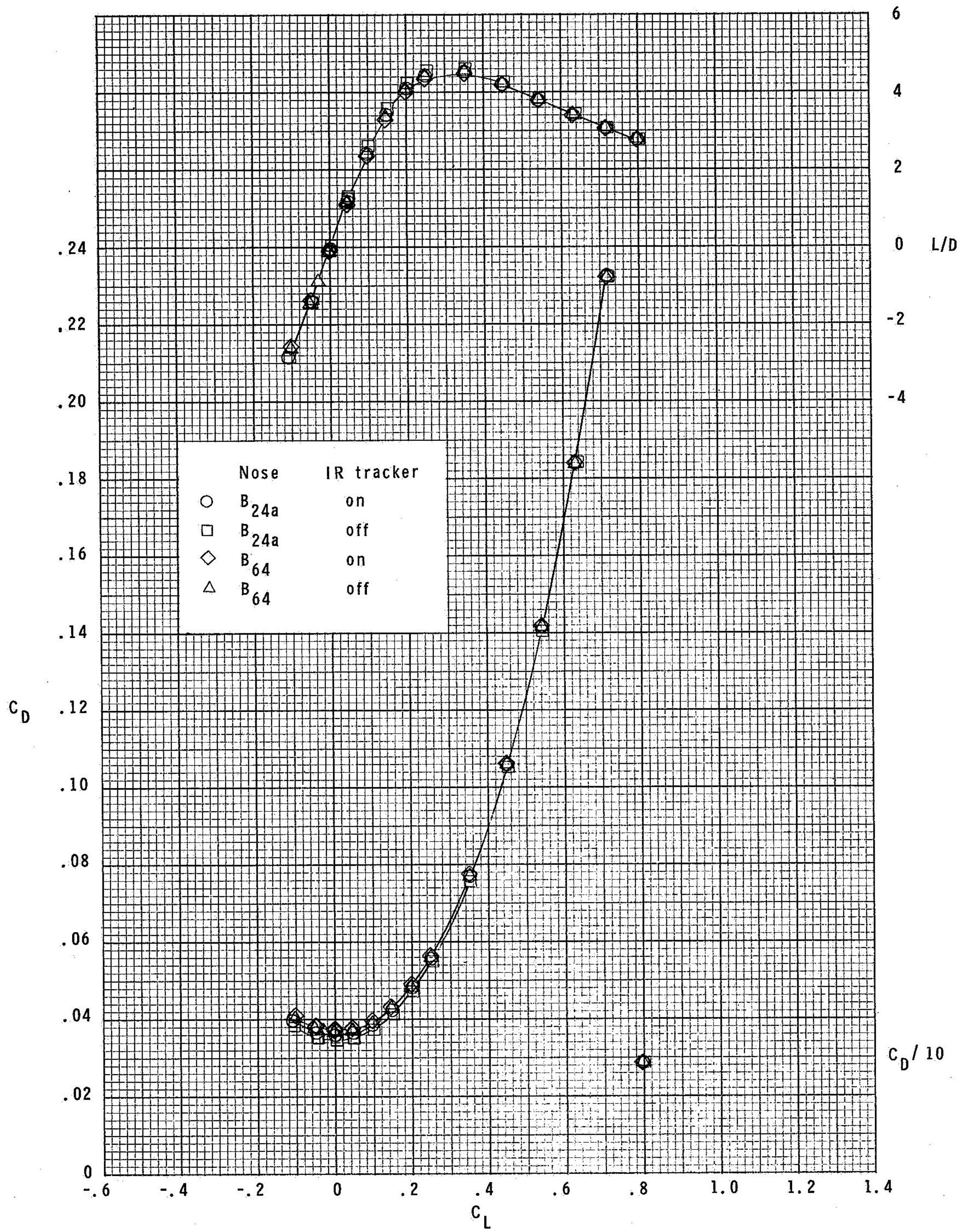
(a) Concluded.

Figure 6.- Continued.



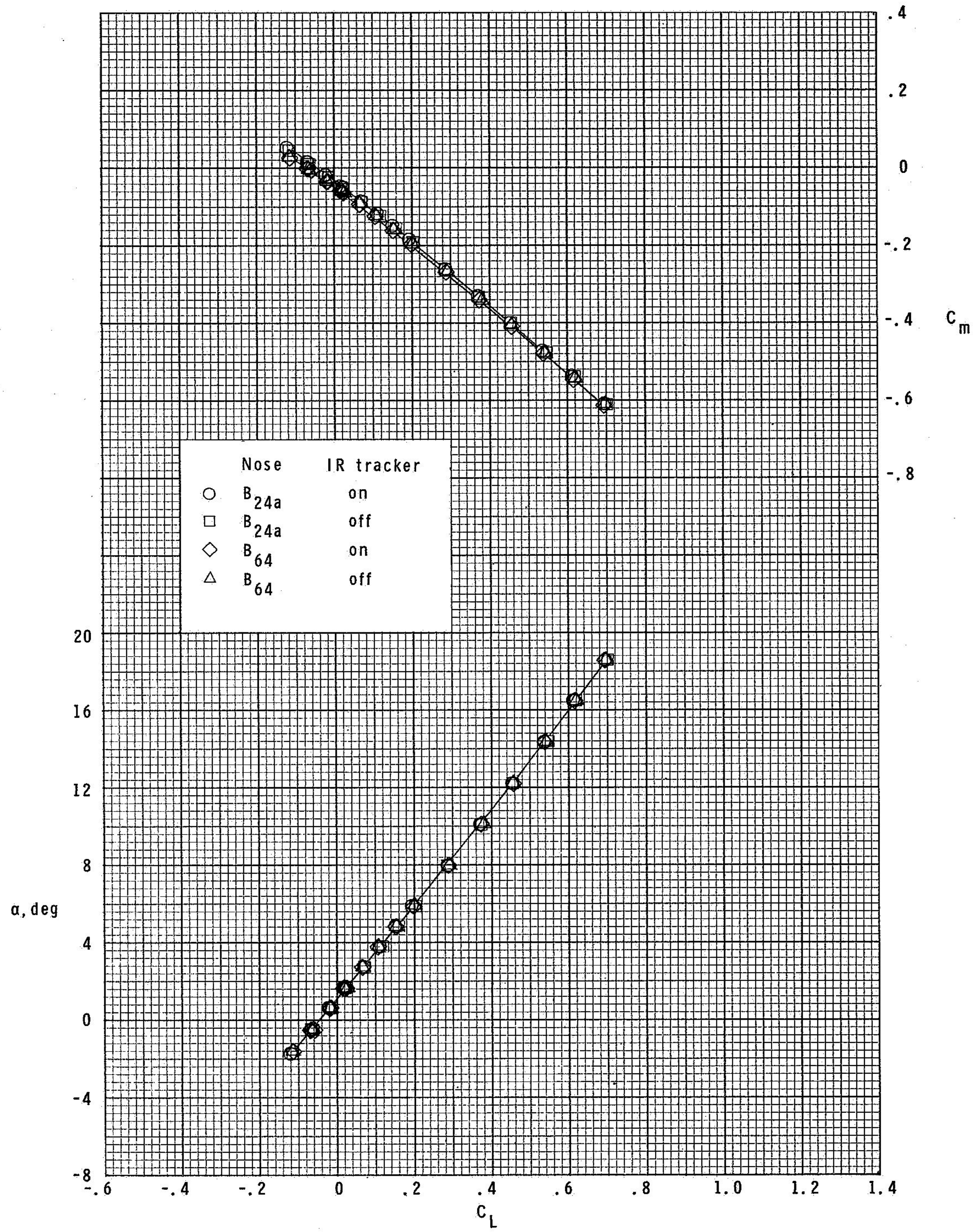
(b) M = 2.16.

Figure 6.- Continued.



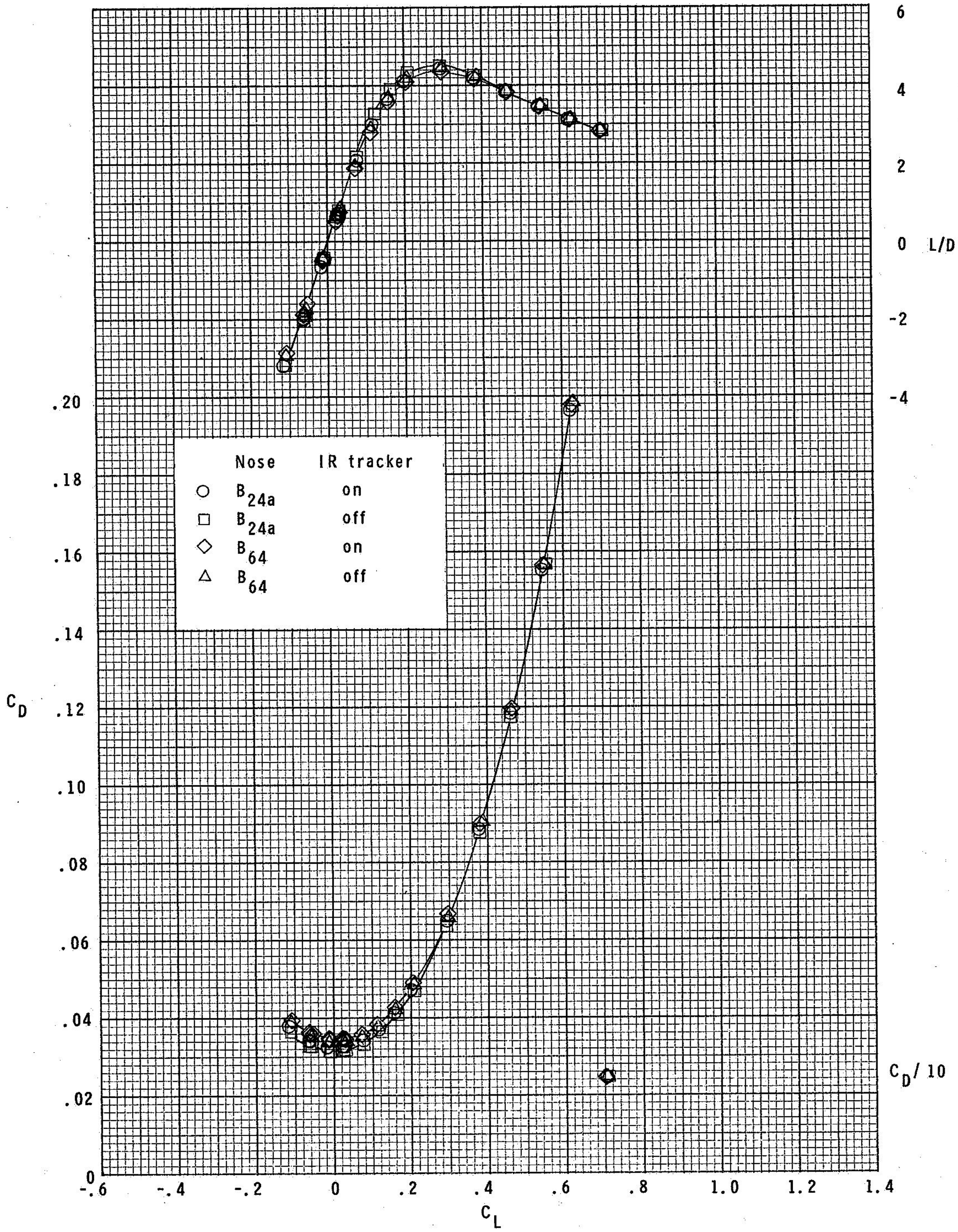
(b) Concluded.

Figure 6.- Continued.



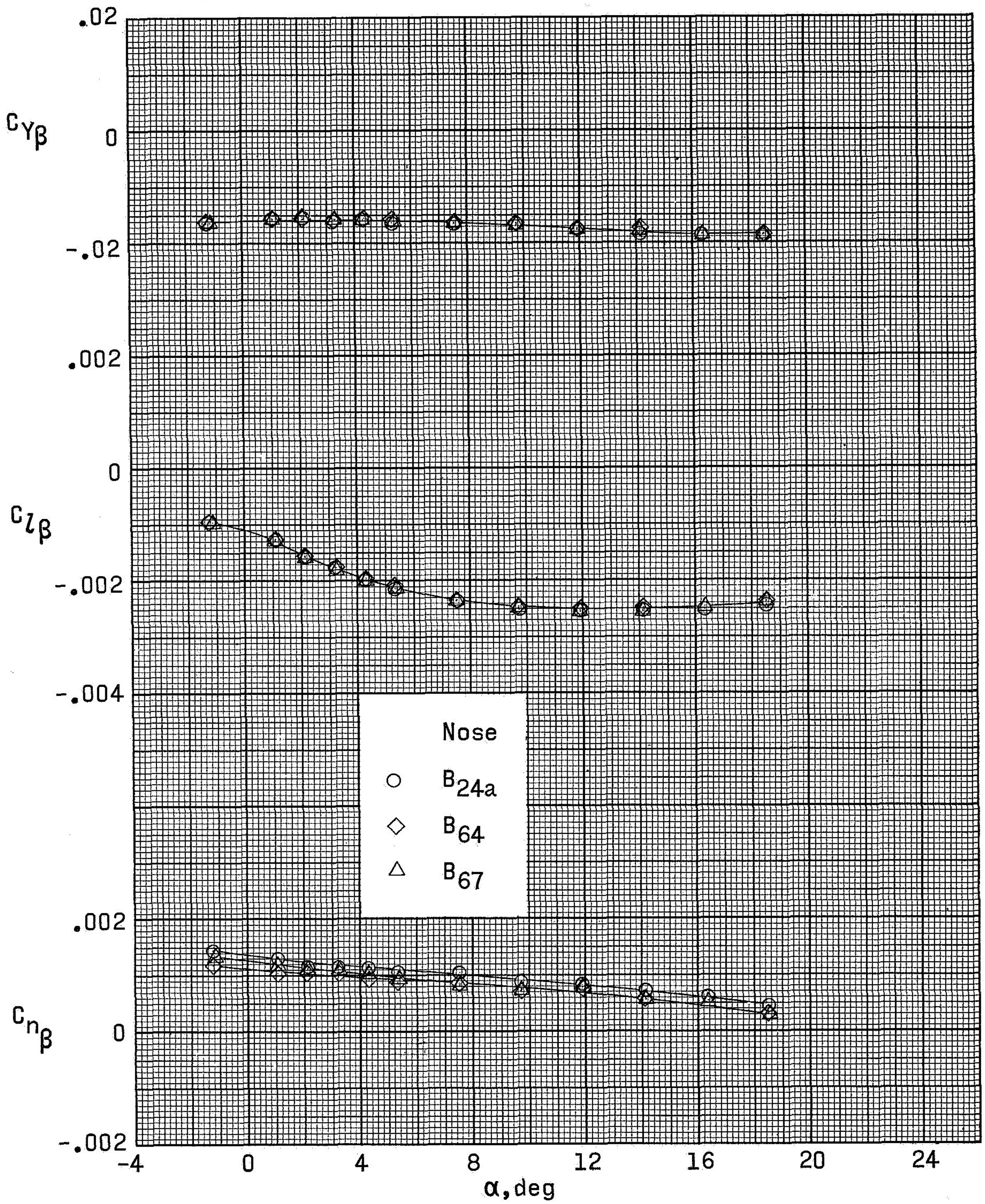
(c) M = 2.50.

Figure 6.- Continued.



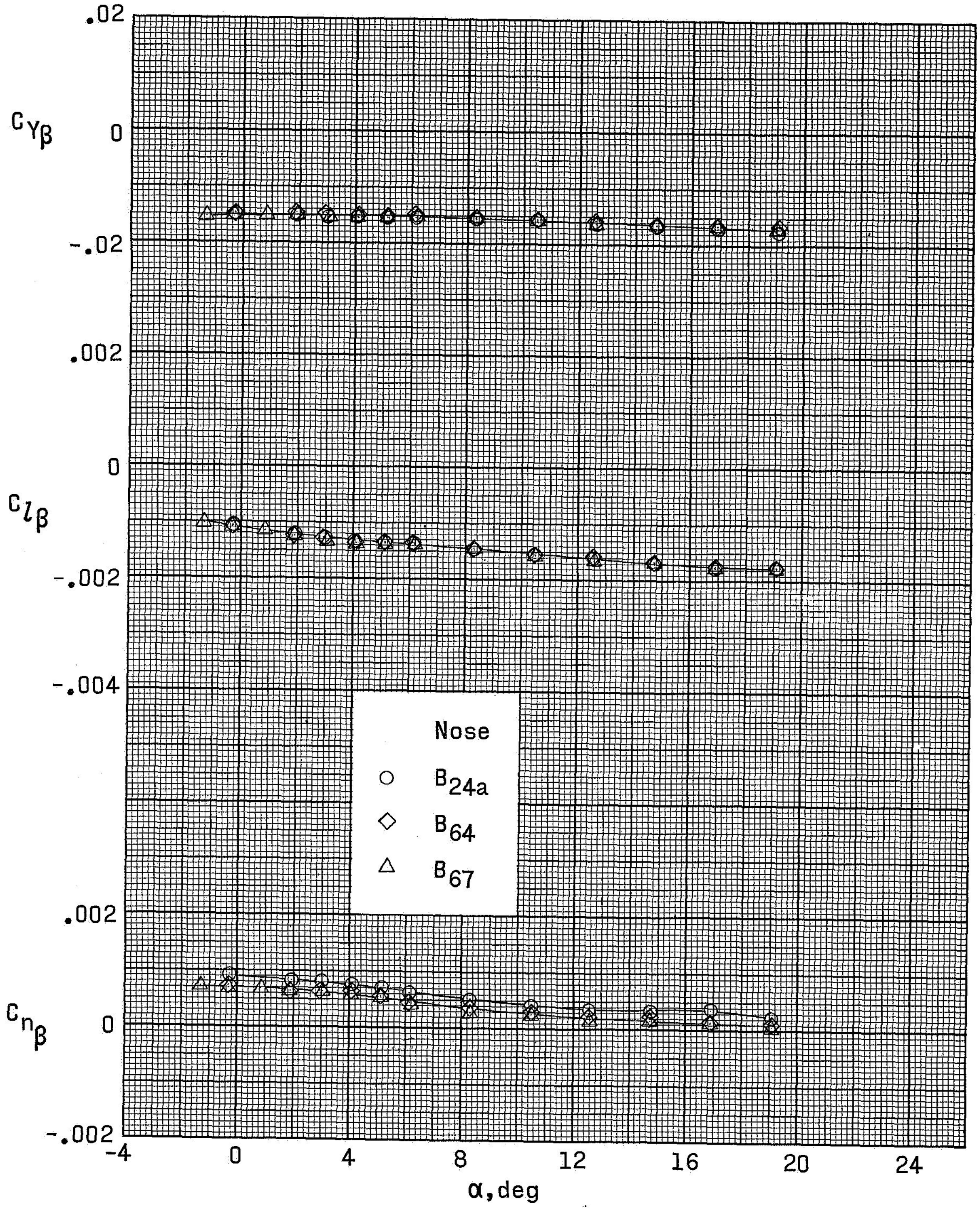
(c) Concluded.

Figure 6.- Concluded.



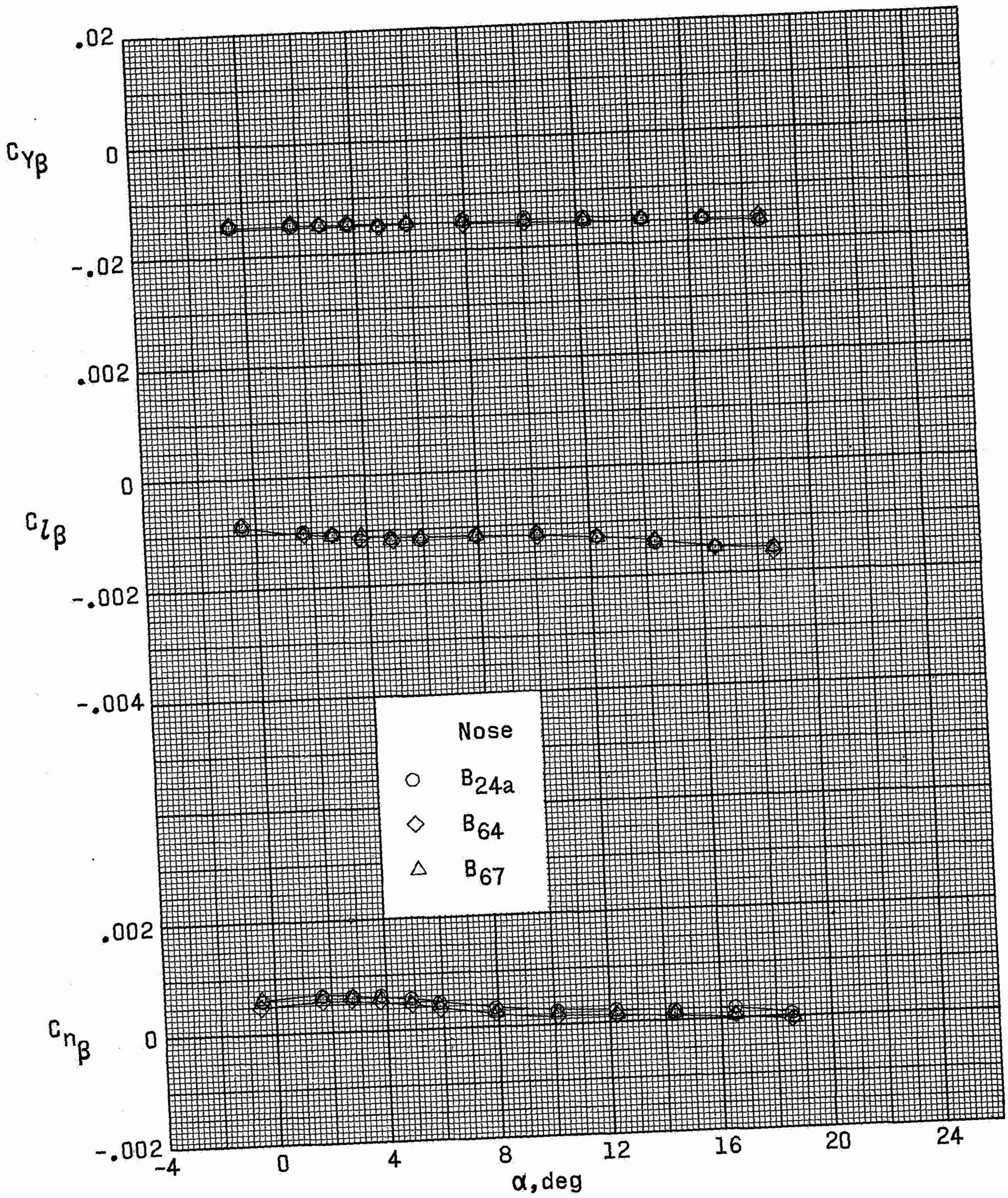
(a) M = 1.60.

Figure 7.- Effects of B_{24a}, B_{64}, and B_{67} noses on the lateral parameters.



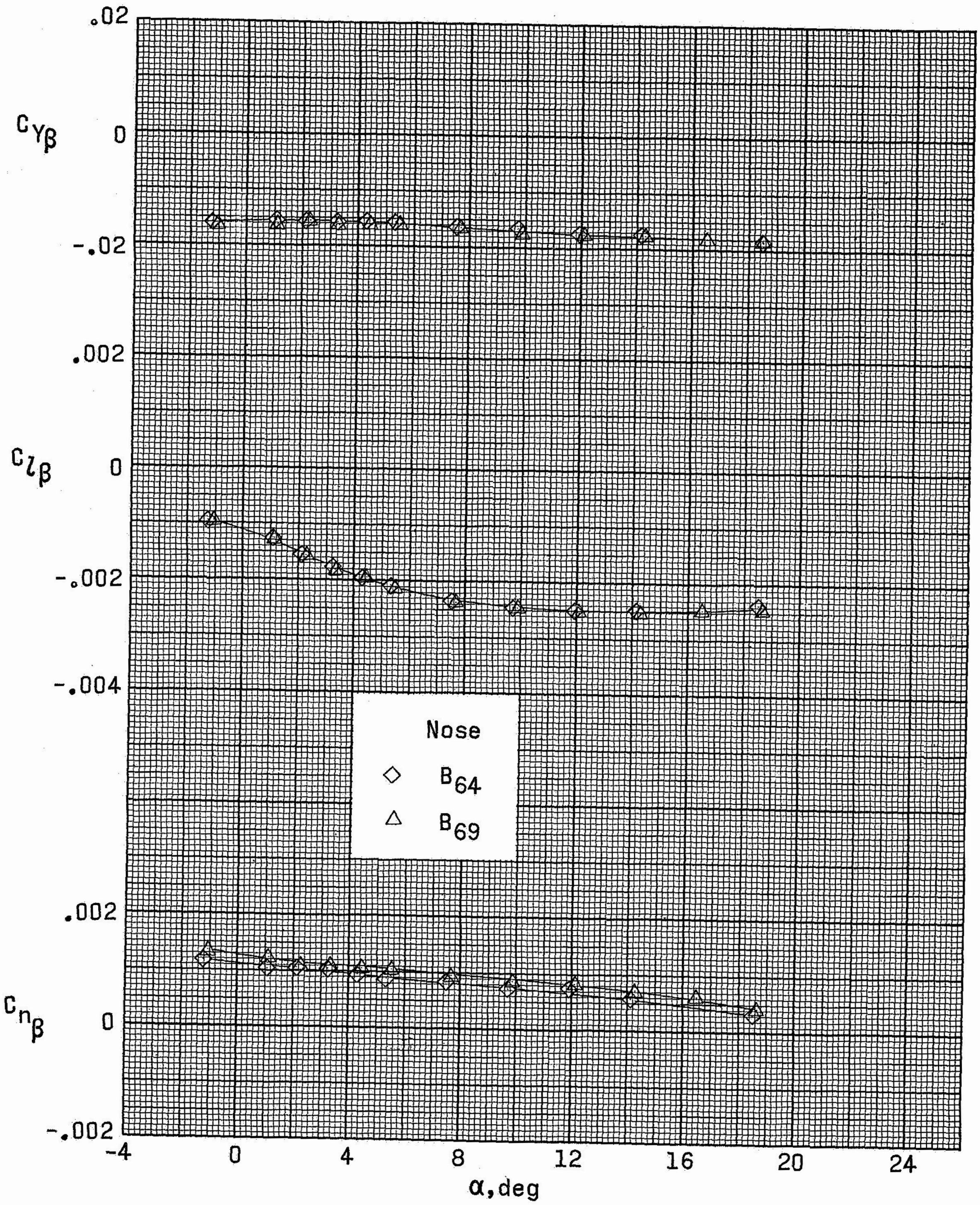
(b) M = 2.16.

Figure 7.- Continued.



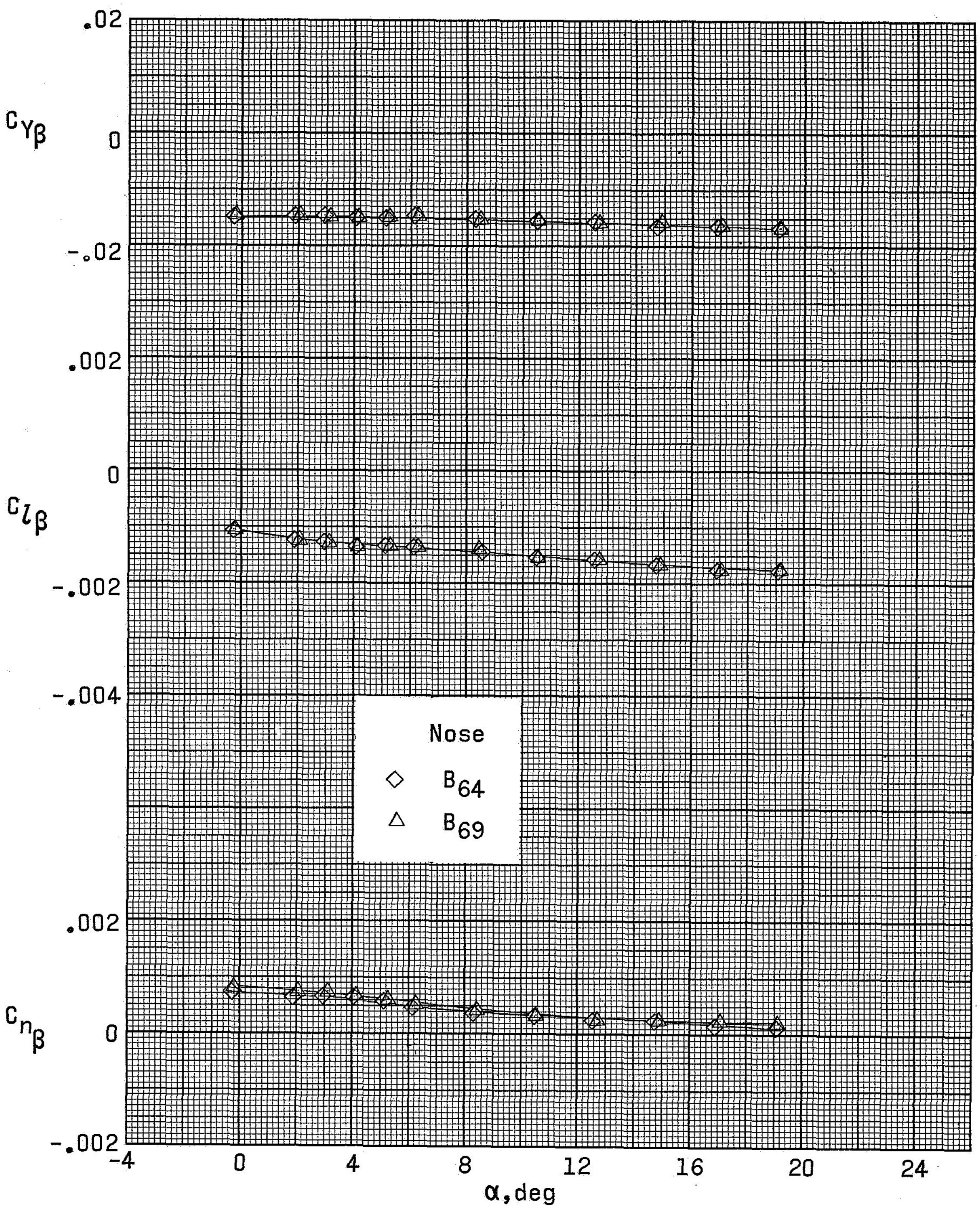
(c) M = 2.50.

Figure 7.- Concluded.



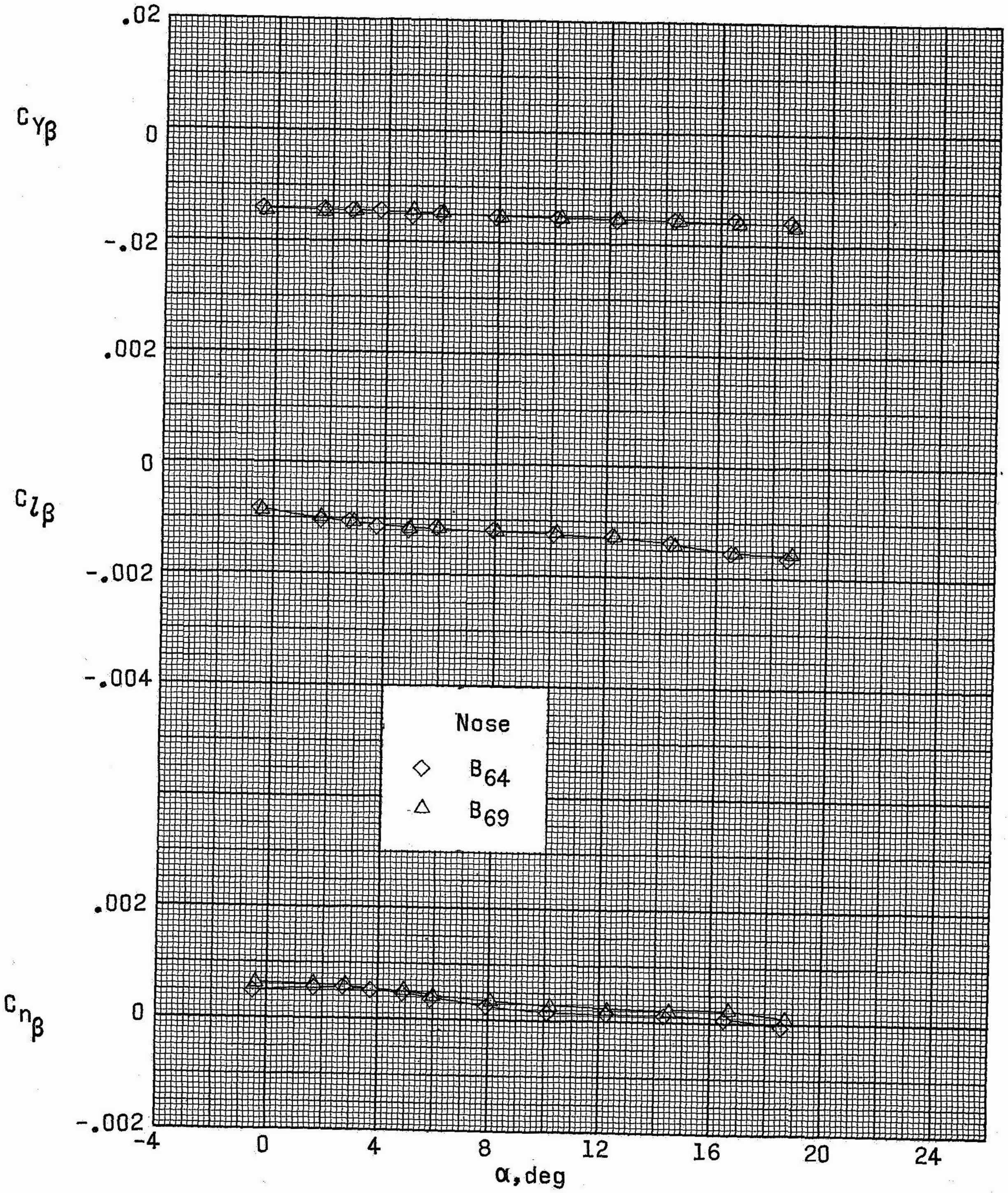
(a) M = 1.60.

Figure 8.- Effects of B_{64} and B_{69} noses on the lateral parameters.



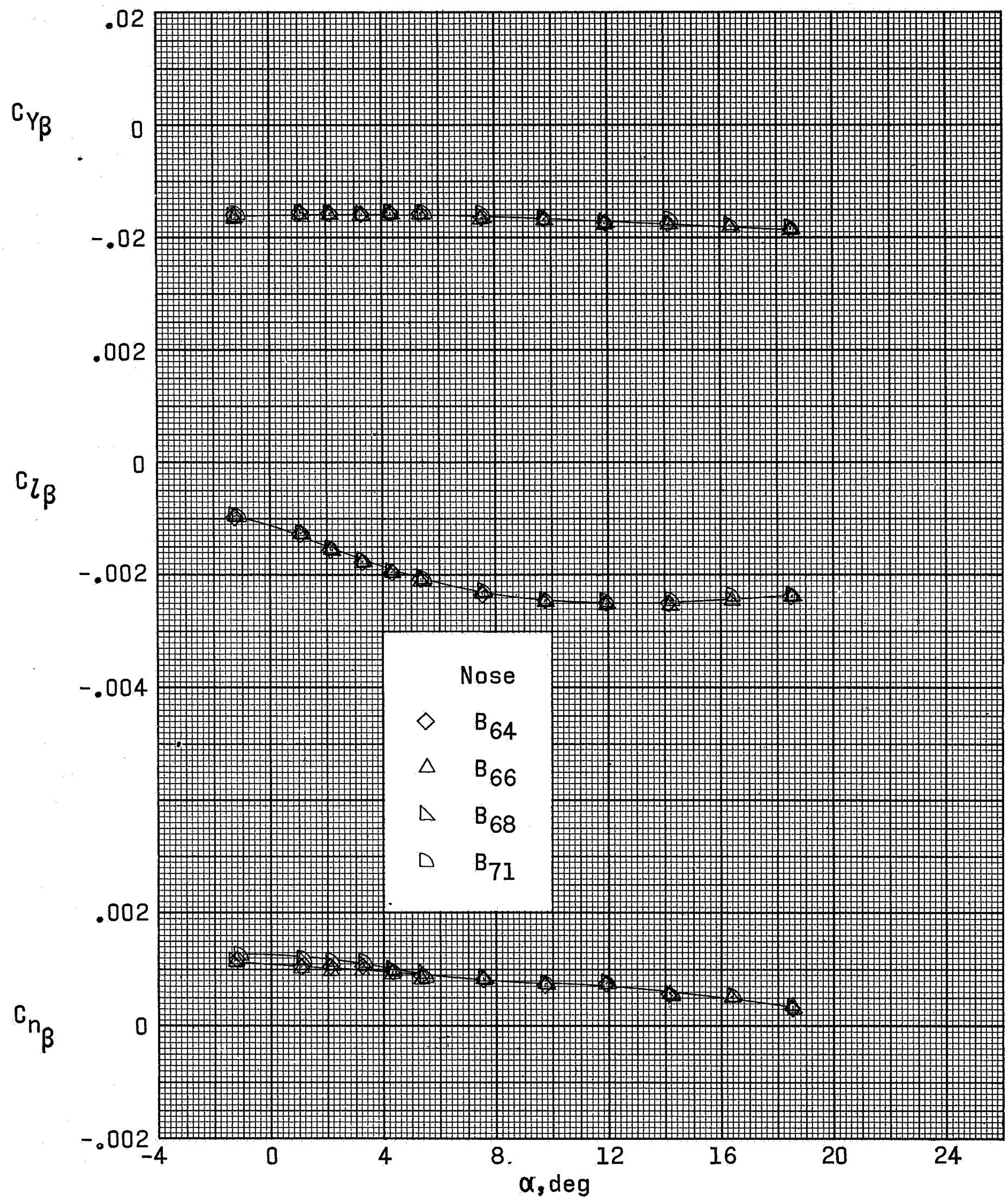
(b) M = 2.16.

Figure 8.- Continued.



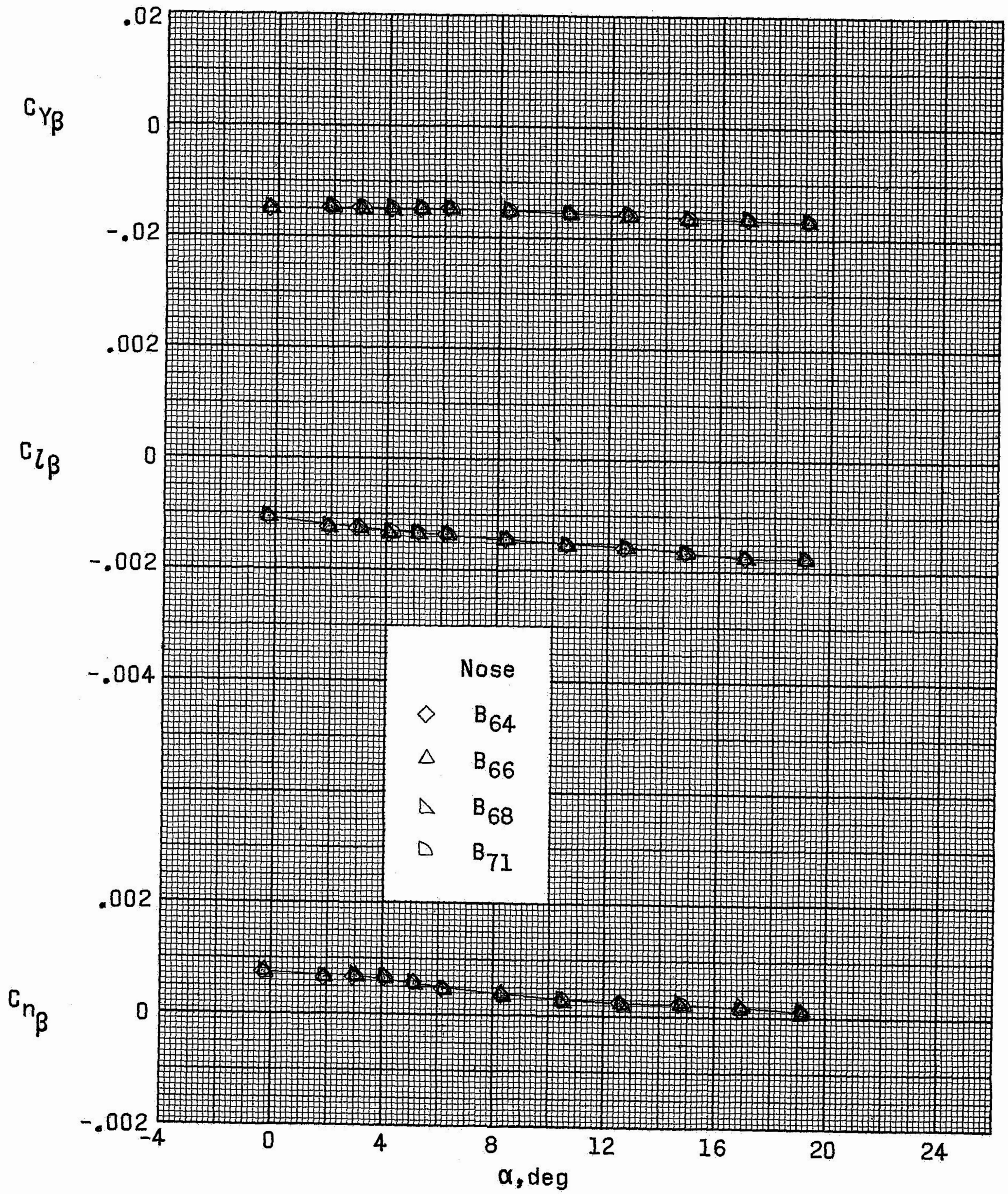
(c) M = 2.50.

Figure 8.- Concluded.



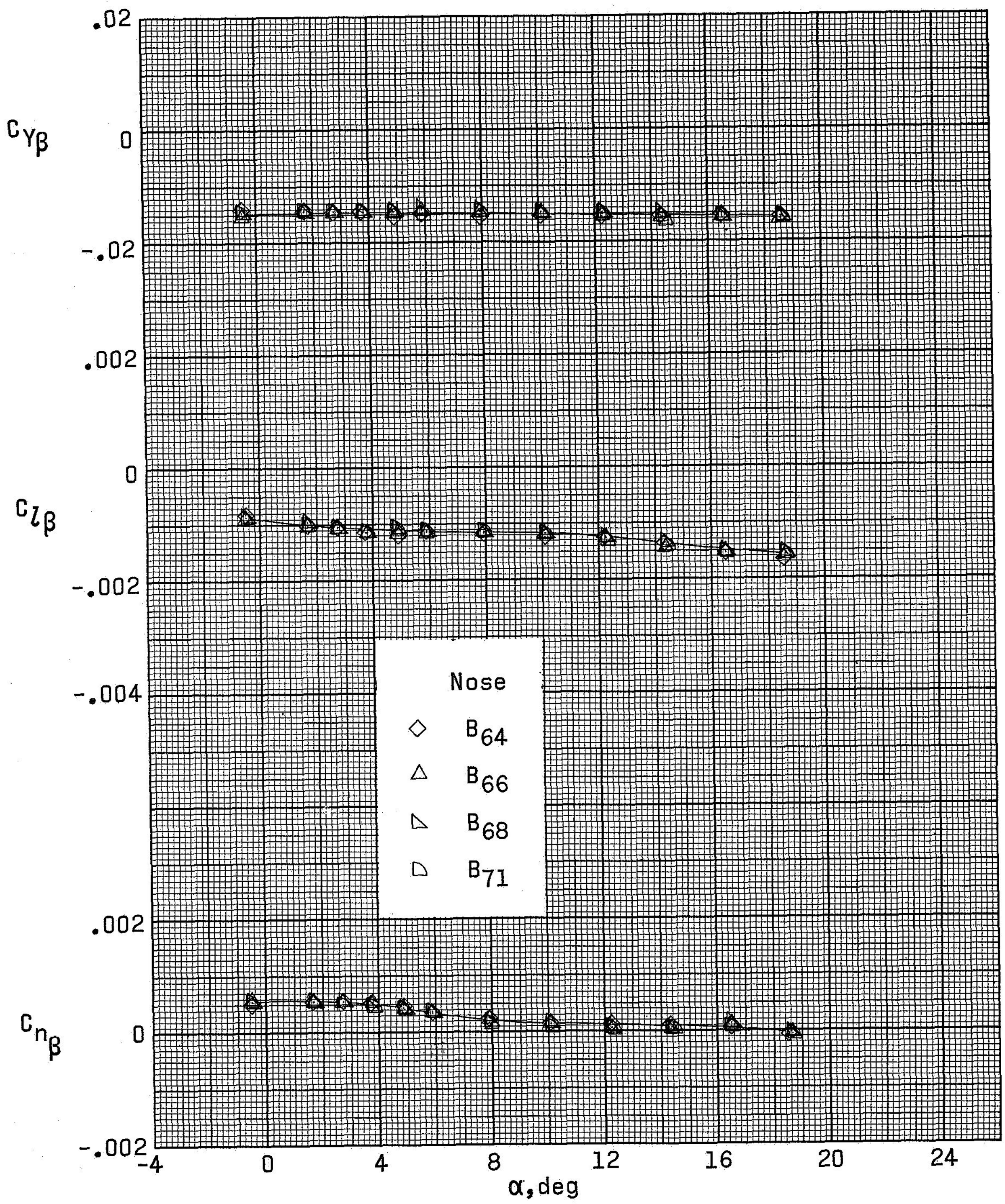
(a) M = 1.60.

Figure 9.- Effects of B_{64}, B_{66}, B_{68}, and B_{71} noses on the lateral parameters.



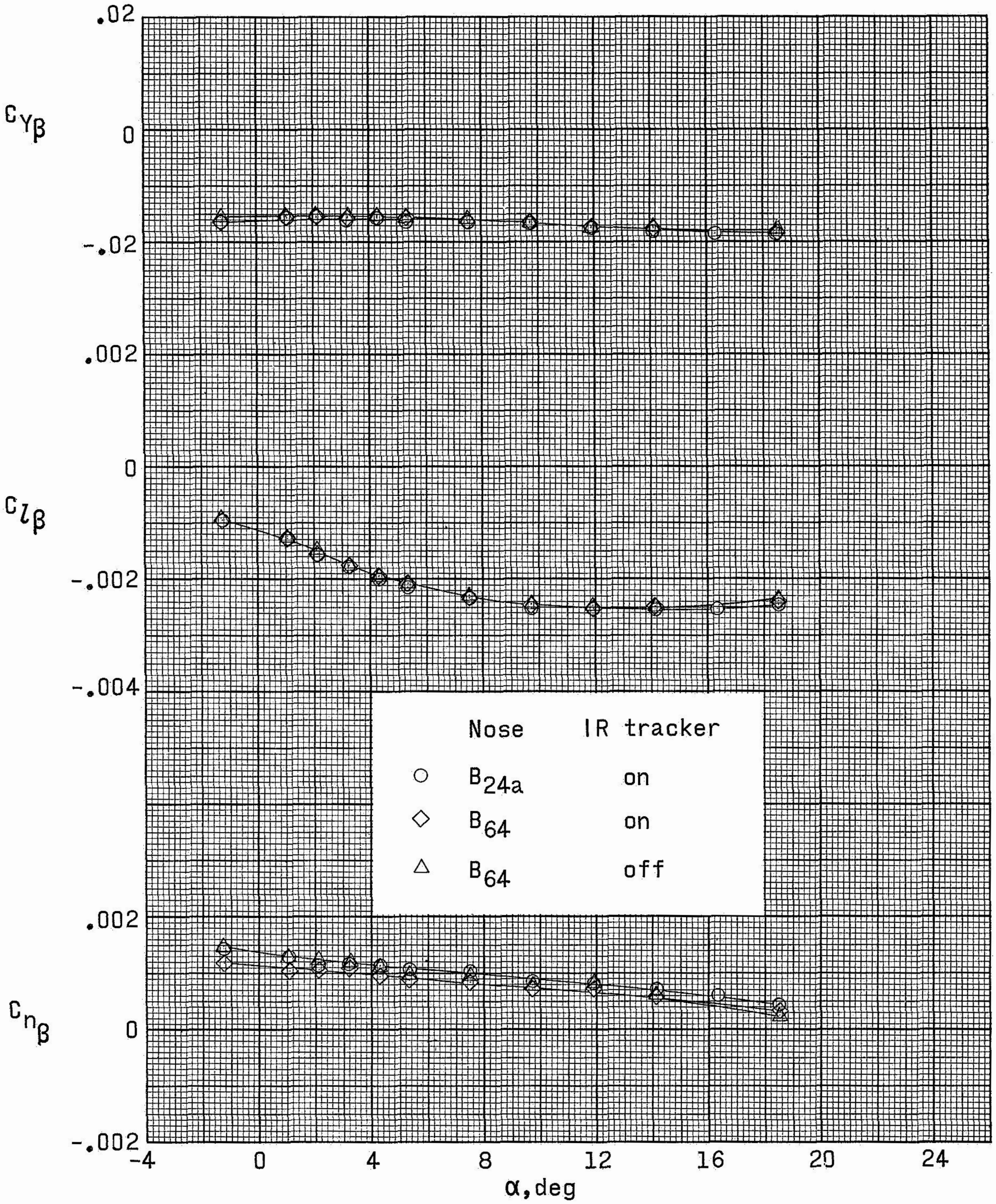
(b) M = 2.16.

Figure 9.- Continued.



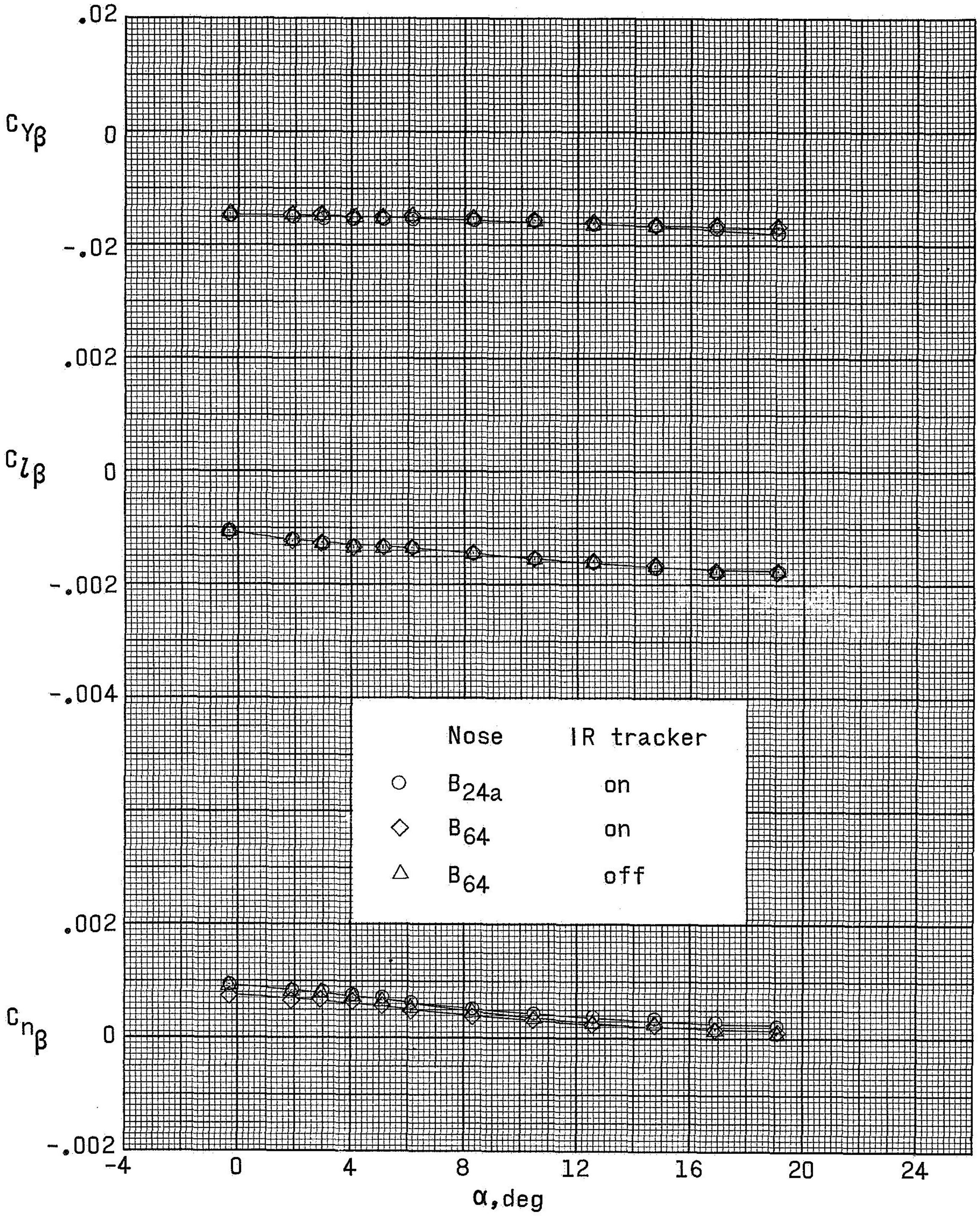
(c) M = 2.50.

Figure 9.- Concluded.



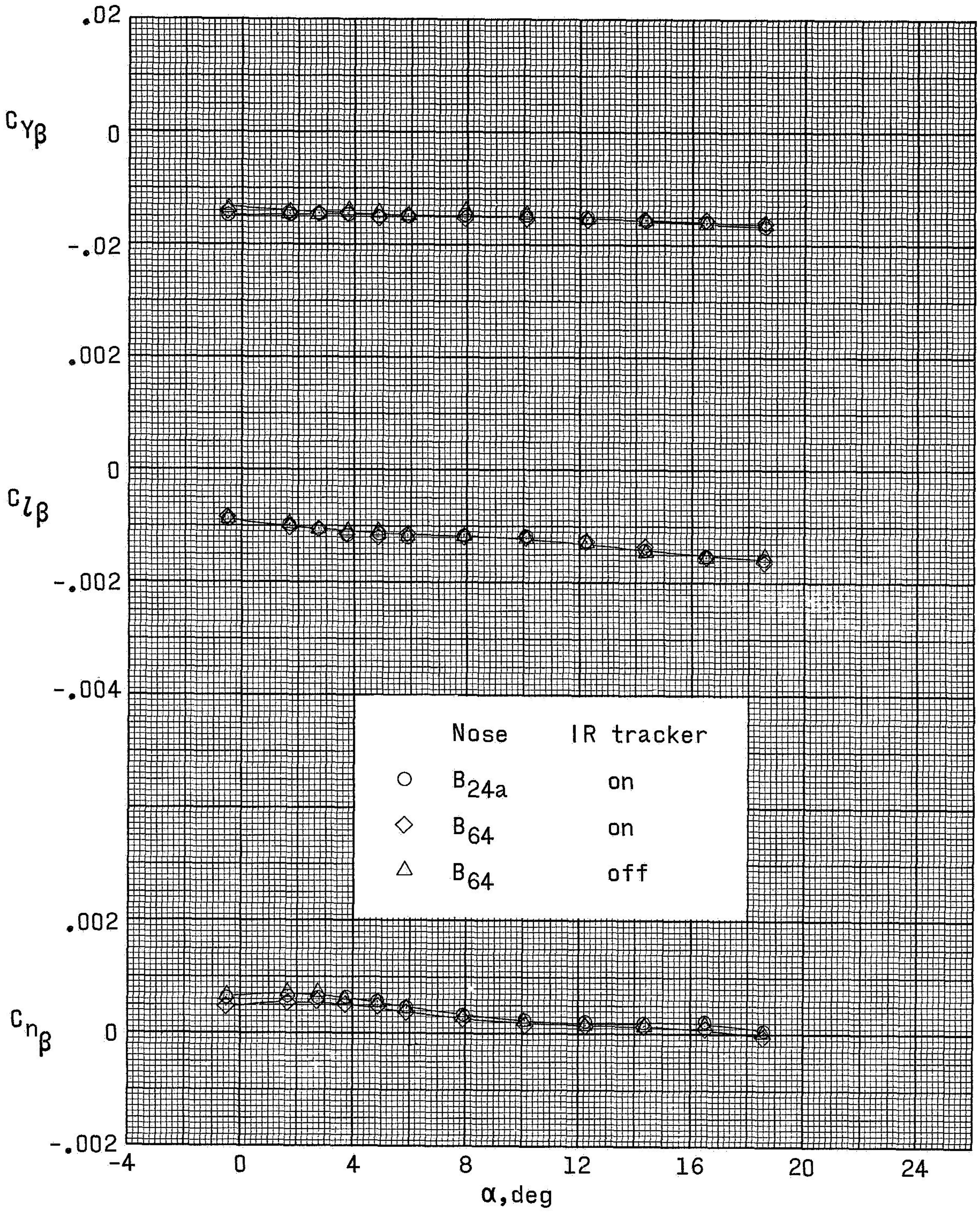
(a) M = 1.60.

Figure 10.- Effect of IR tracker (X_{52}) on the lateral parameters.



(b) M = 2.16.

Figure 10.- Continued.



(c) M = 2.50.

Figure 10.- Concluded.

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